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U.S.
Department
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Farmers'
Bulletins
Nos 801-825.

WASHINGTON
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1919

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U. S. DEPARTMENT OF AGRICULTURE
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FARMERS' BULLETINS
Nos. 801-825

WITH CONTENTS AND INDEX

PREPARED UNDER THE SUPERVISION OF
EDWY B. REID
CHIEF, DIVISION OF PUBLICATIONS

WASHINGTON
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CONTENTS.

FARMERS' BULLETIN NO. 801.—MITES AND LICE ON POULTRY.

	Page.
Mites	3
The common chicken mite	3
Scaly-leg mite, depluming mite, and other mites	10
Chiggers ("red bugs" or harvest mites)	11
Lice	12
Lice on chickens	12
Lice on turkeys	17
Lice on geese and ducks	18
Pigeon lice	19
Lice of the guinea fowl and peafowl	19
Control of poultry lice	19
Sodium fluoride effective against all lice	20
Other remedies for lice	24
Supplemental control measures for all pests	26
Dust baths	26
A method of avoiding poultry pests	26

FARMERS' BULLETIN NO. 802.—CLASSIFICATION OF AMERICAN UPLAND COTTON.

Introduction	3
Classification according to grade	4
Classification according to color	9
Classification according to length of staple	10
Classification according to character	12
Trade names and regional characteristics	14
Classifying by standards	18
Relative values of different classes	22
Comparison of the official cotton standards of the United States for grade with Liverpool standards	25
Classes and conditions of cotton untenderable on future contracts	26
Summary	28

FARMERS' BULLETIN NO. 803.—HORSE-BREEDING SUGGESTIONS FOR FARMERS.

Profit in breeding farm mares	3
Selecting breeding and working mares	4
Uniformity of the mares	4
Soundness	6
Selecting a stallion	8
Mating considerations	9
Feeding and management of mares in foal	11
Abortions	14
Approaching parturition	14
Parturition	15
Care of the foal	15
Feeding after foaling	16
Raising the orphan foal	17
Weaning	18
Feeding and management of young horses	19
Summary	21

FARMERS' BULLETIN NO. 804.—APHIDS INJURIOUS TO ORCHARD FRUITS, CURRANT, GOOSEBERRY, AND GRAPE..

Page.
Aphids in general 4
Apple aphids 5
Quince aphids 18
Pear aphids attacking the foliage 18
Plum aphids 19
Cherry aphids 22
Peach aphids 25
Currant and gooseberry aphids 27
Grape aphids attacking the foliage 32
Natural enemies of aphids 33
Control measures 34

FARMERS' BULLETIN NO. 805.—THE DRAINAGE OF IRRIGATED FARMS.

Need of drainage on irrigated lands 3
Beneficial results of draining irrigated lands 4
Practical drainage requirements 8
Required depth of drains 9
Spacing and location of drains 12
Types of drains 14
Sizes of drains 16
Construction methods 18
Devices 22
Costs 26
Alkali reclamation 26
Maintenance 29
Necessity and advantages of cooperation 30
Conclusions 31

FARMERS' BULLETIN NO. 806.—STANDARD VARIETIES OF CHICKENS. I. THE AMERICAN CLASS.

The kind of chicken the farmer wants 3
Characteristics of the general-purpose breeds 3
Breeds and varieties 4
  The Plymouth Rock 5
  The Wyandotte 11
  The Java 14
  The Dominique 15
  The Rhode Island Red 17
  The Buckeye 18

FARMERS' BULLETIN NO. 807.—BREAD AND BREAD MAKING IN THE HOME.

Importance of bread in the diet 3
Qualities of good bread 4
Principal requirements in bread making 5
Recipes for making bread 14
How to judge bread 23
Nutritive value of bread and its place in the diet 24

FARMERS' BULLETIN NO. 808.—HOW TO SELECT FOODS. I. WHAT THE BODY NEEDS.

Purpose of this bulletin 3
The day's food 4
What the day's food should provide 7
Grouping foods to show their uses 8
How to tell whether or not the diet is adequate 11
General suggestions 13

FARMERS' BULLETIN NO. 809.—MARKETING LIVE STOCK IN THE SOUTH. SUGGESTIONS FOR IMPROVEMENT.

Page.
Need of better local markets for live stock........ 3
Local markets and methods of marketing commonly followed........ 3
Local marketing of stock on foot........ 5
Cooperative live stock shipping........ 5
Tennessee lamb and wool marketing clubs........ 7
A Mississippi commercial club's marketing plan........ 8
Cattle sales of South Carolina........ 9
Marketing farm-cured meats........ 10
The southern ice plant as a local market........ 11
Municipal or public abattoir as an aid in the local marketing of live stock........ 12
Meeting market demands........ 13

FARMERS' BULLETIN NO. 810.—EQUIPMENT FOR FARM SHEEP RAISING.

Drawings and bills of materials........ 3
Important features of buildings for sheep........ 6
A barn for the exclusive use of sheep........ 10
A combination horse, cattle, and sheep barn........ 13
A closed sheep shed........ 15
An open sheep shed........ 16
A feed lot for fattening lambs........ 17
Feed racks........ 18
Grain troughs........ 21
Lambing pens and creeps........ 22
Fencing and hurdles........ 23
Miscellaneous equipment........ 25

FARMERS' BULLETIN NO. 811.—THE PRODUCTION OF BABY BEEF.

Tendency toward early marketing of beef animals........ 3
Why baby beef feeding is profitable........ 3
When production of baby beef is not advisable........ 4
Breeds suitable for baby-beef production........ 7
Type of cows to use........ 7
Type of bulls to be used........ 8
Type of calves suitable for baby beef........ 9
Management and feeding of breeding herd........ 10
Calf management and feeding........ 17
Hogs following baby beeves........ 22

FARMERS' BULLETIN NO. 812.—HOW LIVE STOCK IS HANDLED IN THE BLUEGRASS REGION OF KENTUCKY.

Importance of knowing the best practice........ 3
What the bluegrass region farmer may do to increase his profits through live stock........ 3
Utilization of waste products by means of animals........ 6
Feeding practice and cost of feed for different kinds of animals common on bluegrass farms........ 7
Analyses of business on six individual farms........ 11

FARMERS' BULLETIN NO. 813.—CONSTRUCTION AND USE OF FARM WEIRS.

Need of farm weirs........ 3
Definitions........ 3
Advantages and disadvantages of weirs with complete constructions........ 4
Weir box and weir pond........ 5
Weir crests and sides........ 9
Weir gauge........ 10

FARMERS' BULLETIN NO. 813.—CONSTRUCTION AND USE OF FARM WEIRS—Continued.

Page.
Rectangular weirs........ 12
Cipolletti weirs........ 14
Ninety-degree triangular-notch weirs........ 15
Units of measure........ 17

FARMERS' BULLETIN NO. 814.—BERMUDA GRASS.

Introduction........ 3
Description of Bermuda grass........ 3
History........ 4
Climatic adaptations........ 5
Adaptations to soil........ 5
Distribution in the United States........ 6
Varieties........ 7
Seed production........ 8
Propagation........ 8
Pasture value........ 10
Bermuda grass for hay........ 13
Bermuda grass for turf........ 13
Bermuda grass for soil binding........ 14
Market value........ 14
Feeding value........ 15
Eradication........ 18
Summary........ 18

FARMERS' BULLETIN NO. 815.—ORGANIZATION, FINANCING, AND ADMINISTRATION OF DRAINAGE DISTRICTS.

Introduction........ 3
Development of drainage organizations........ 4
Factors to be considered before organizing a drainage district........ 5
Procedure to effect a drainage organization........ 7
Engineering features........ 11
Determination and confirmation of benefits........ 13
Levy of drainage tax........ 18
Financing of drainage districts........ 19
Payment of bonds and interest........ 26
Records of drainage districts........ 29
Administration of drainage districts........ 32
Necessity for adequate maintenance........ 35
Summary........ 36

FARMERS' BULLETIN NO. 816.—MINOR ARTICLES OF FARM EQUIPMENT.

Extent of minor equipment........ 3
List of articles........ 4
Total cost........ 13
Advantage of making a list........ 14

FARMERS' BULLETIN NO. 817.—HOW TO SELECT FOODS. II. CEREAL FOODS.

Wise use of cereal foods........ 3
Kinds of cereals........ 5
Prepared cereals........ 5
Dishes made of cereals........ 6
How much cereal food should be used........ 8
Bread........ 9
Breakfast cereals........ 14

FARMERS' BULLETIN NO. 817.—HOW TO SELECT FOODS. II. CEREAL FOODS—Continued.

Page.
Cakes, pastries, puddings, sauces, and other dishes rich in cereal.......... 16
Economics with cereal foods.......... 17
Potatoes and sweet potatoes used like cereals.......... 21
Summary.......... 21

FARMERS' BULLETIN NO. 818.—THE SMALL VEGETABLE GARDEN. SUGGESTIONS FOR UTILIZING LIMITED AREAS.

Essentials of gardening.......... 3
Planning the small garden.......... 4
Choosing crops.......... 8
Aids to earliness (hotbed, seed box, cold frame).......... 9
Tools.......... 12
Preparing the soil.......... 14
Planting vegetables in the open.......... 16
Gardener's planting table.......... 18
Cultivation.......... 21
Irrigation.......... 25
Protecting plants from diseases and pests.......... 25
Cultural suggestions for the commoner vegetables.......... 28
Vegetables for winter use.......... 42
Fruits in the small garden.......... 44

FARMERS' BULLETIN NO. 819.—THE TOBACCO BUDWORM AND ITS CONTROL IN THE SOUTHERN TOBACCO DISTRICTS.

Description of the insect in its different stages.......... 3
Nature and extent of injury.......... 4
History and distribution in the United States.......... 4
Seasonal history.......... 5
Food plants.......... 6
Insect enemies.......... 6
Control measures.......... 6

FARMERS' BULLETIN NO. 820.—SWEET CLOVER: UTILIZATION.

General statement of the uses of sweet clover.......... 3
Sweet clover as a pasture crop.......... 4
Sweet-clover hay.......... 10
Sweet clover as a silage crop.......... 20
Sweet clover as a soiling crop.......... 22
Sweet clover as a feed.......... 23
Sweet clover as a soil-improving crop.......... 28
Sweet clover in rotations.......... 31
Sweet clover as a honey plant.......... 32

FARMERS' BULLETIN NO. 821.—WATERMELON DISEASES.

Need of cooperation for control of watermelon diseases.......... 3
Descriptive key to watermelon diseases.......... 3
Watermelon wilt.......... 4
Root-knot.......... 6
Anthracnose.......... 6
Stem-end rot.......... 11
Minor diseases.......... 17
Summary of control measures.......... 18

FARMERS' BULLETIN NO. 822.—LIVE-STOCK CLASSIFICATIONS AT COUNTY FAIRS.

Page.
Educational value of live-stock exhibitions 3
Cooperation with live-stock organizations 3
Uniformity of classification 4
Special features 4
Selection of superintendents, judges, etc 5
Arrangement of exhibits 5
Announcement of judges, prize winners, etc 6
Exhibition of prize winners 6
Rules 6
Premiums 7
Classifications 8

FARMERS' BULLETIN NO. 823.—SUGAR-BEET SIRUP.

Growing sugar beets for sirup 3
Making sirup from sugar beets 9
Quality of the sirup 12
Uses of beet sirup 12

FARMERS' BULLETIN NO. 824.—HOW TO SELECT FOODS. III. FOODS RICH IN PROTEIN.

Importance of protein and foods which supply it 3
How much protein is needed 4
How much protein different foods supply 6
Different kinds of protein 9
Cost of protein in different kinds of food 10
Use of protein-rich foods in cookery 12
Points to remember about protein foods 18

FARMERS' BULLETIN NO. 825.—PIT SILOS.

Adaptations and advantages of pit silos 3
Location; character of soil required 4
Size of silo 4
Method of construction 5
Hoisting devices and feeding equipment 10
Poisonous gases in pit silos 12
Points to be emphasized 13
Publications 14

MITES AND LICE ON POULTRY

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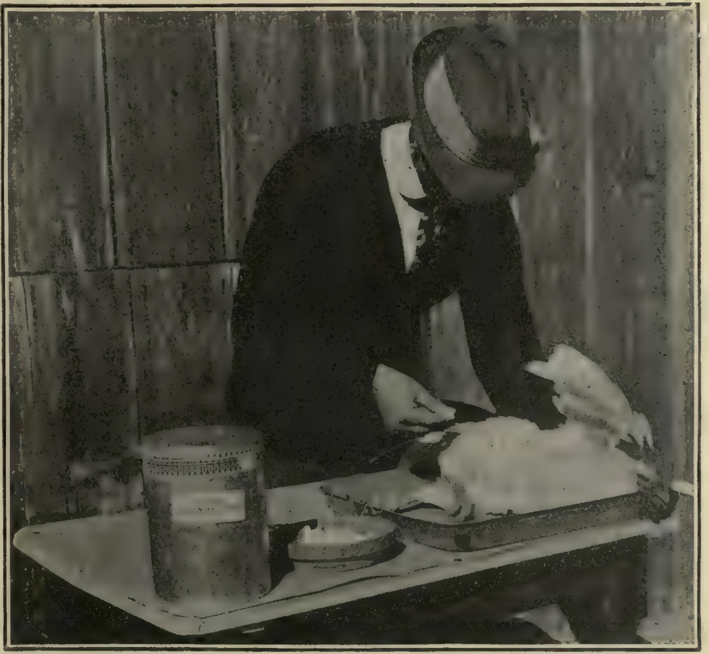

"Pinch method" of applying sodium fluorid to a fowl infested with lice

FARMERS' BULLETIN 801

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. May, 1917

Additional copies of this bulletin may be obtained from the
Division of Publications, U. S. Department of Agriculture

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ASIDE from the chicken tick and the sticktight flea, the most important external parasites of fowls are the common red mite, the scaly-leg mite, and various lice.

The common mite sucks blood from the fowls and breeds in the cracks of the roosts and buildings. It may be destroyed by two or three applications of crude petroleum or certain coal-tar products to the roosts and buildings.

Scaly leg is caused by a small mite which may be destroyed by dipping the legs in crude petroleum.

In addition to a description of mites and lice this bulletin tells of a new but cheap and effective insecticide for use in destroying poultry lice. It is sodium fluorid, a white powder, which can be obtained through druggists. A single application, which costs about half a cent, will destroy all of the lice on a bird. Hundreds of fowls have been treated in the experiments conducted, but no injury whatever to them has occurred. Full instructions regarding methods of application are given in the bulletin.

MITES AND LICE ON POULTRY.

CONTENTS.

	Page.
Mites	3
The common chicken mite	3
Scaly-leg mite, depluming mite, and other mites	10
Chiggers ("red bugs" or harvest mites)	11
Lice	12
Lice on chickens	12
Lice on turkeys	17
Lice on geese and ducks	18
Lice—Continued.	
Pigeon lice	19
Lice of the guinea fowl and peafowl	19
Control of poultry lice	19
Sodium fluorid effective against all lice	20
Other remedies for lice	24
Supplemental control measures for all pests	26
A method of avoiding poultry pests	26

External parasites are one of the most important factors operating to retard the development of the poultry industry, but it is difficult to determine which of the parasites are of greatest importance. Both lice and mites are found in practically every locality where poultry are raised. Where present in any considerable numbers both lice and mites reduce egg production and hinder the growth and reduce the quality of flesh of all classes of poultry.

MITES.

THE COMMON CHICKEN MITE.[1]

Poultry raisers are all too familiar with the common red or gray mite which infests poultry houses. In general those who are making a specialty of poultry raising have comparatively little trouble with mites, or at least they keep them reduced to a point where they are of little importance. On the other hand, farmers and others who raise poultry as an incident to other operations frequently find their chicken houses overrun by mites. The attack of this blood-sucking mite is of an insidious nature which does not readily draw attention to its presence, and often the poultryman is not aware of an infestation until he is attracted to it by the irritation produced by mites on his own body through coming in contact with the infested coops. The presence of the pest may be determined readily by the detection of small areas on the boards specked with black and white as though dusted with salt and pepper. This is the excrement of the mites, which are hidden in adjacent cracks or rough places. More careful examination will reveal masses of mites in hiding, together with their eggs and the silvery skins cast by the young. In moderately infested poultry houses the injury to the fowls is not very apparent, but the constant blood loss and irritation are shown by decreased egg production and the poor condition of the flesh of fowls. In heavily infested coops it is not unusual for the chickens to become droopy and weak, with pale comb and wattles. Sitting hens desert their nests and thus ruin the eggs or, as is often the case, they are found dead on the nest, being killed outright by the attack of thousands of mites. In extreme cases a considerable percentage of the fowls succumb, even though not sitting, and all are so weakened as to be very susceptible to various diseases.

---

[1] *Dermanyssus gallinae* De Geer.

DISTRIBUTION AND ABUNDANCE.

While the species sometimes becomes very numerous in the chicken houses in the northern part of the United States, the shorter breeding season there usually makes it of less importance than in the South where breeding continues throughout the year with little or no interruption. Although many assert that dampness has much to do with the abundance of the chicken mite, experience has shown that it occurs in rather greater numbers in the semiarid and arid regions of the Southwest than in the more humid parts of the South.

LIFE HISTORY AND HABITS.

Blood is absolutely essential for the development of this mite in all stages. The mite feeds almost entirely at night, except that it often feeds on hens on nests.

Chickens may carry a few mites (sometimes a hundred or more) in their feathers during the day following a night spent in infested quarters, but most of these leave the host during the following night. In some cases mites may remain on chickens during three days and nights, but nearly all become engorged and leave them by the third night.

Within 12 to 48 hours after receiving a meal of blood the mature female deposits from three to seven pearly white and elliptical eggs (see fig. 1), laid singly in the cracks in which the adults are hiding. The operation of feeding and depositing is repeated as many as eight times, and from 25 to 35 eggs in all are deposited.

In summer the eggs hatch in about two days, and one to two days later, without feeding, the larvæ shed their skins and become nymphs (see fig. 2). With a very short rest these light-colored nymphs engorge with blood, secrete themselves, and molt their skins the second time 30 to 48 hours after having fed. These mites of the second nymphal stage soon engorge again, shedding their skins one to two days later and becoming adults. The grayish-colored unfed adult is shown in figure 3, and the engorged female, dark red in color and quite plump, in figure 4.

Thus the chicken mite reproduces very rapidly, the complete life cycle from egg to adult requiring not more than seven days.

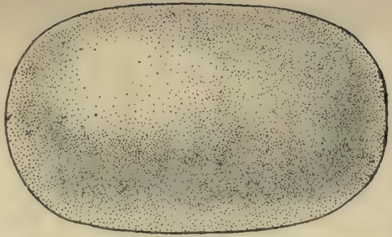

FIG. 1.—Egg of the chicken mite (*Dermanyssus gallinae*). Greatly enlarged. (Original.)

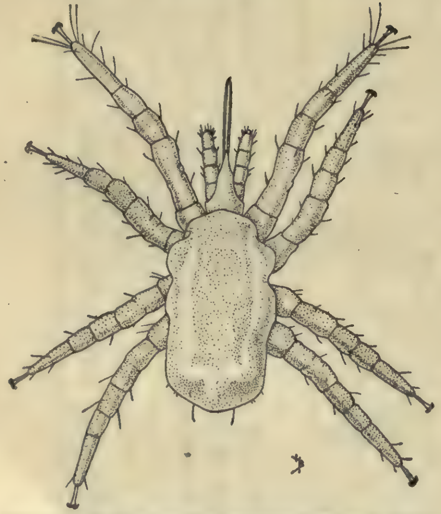

FIG. 2.—First nymphal stage of the chicken mite, unfed. Greatly enlarged. (Original.)

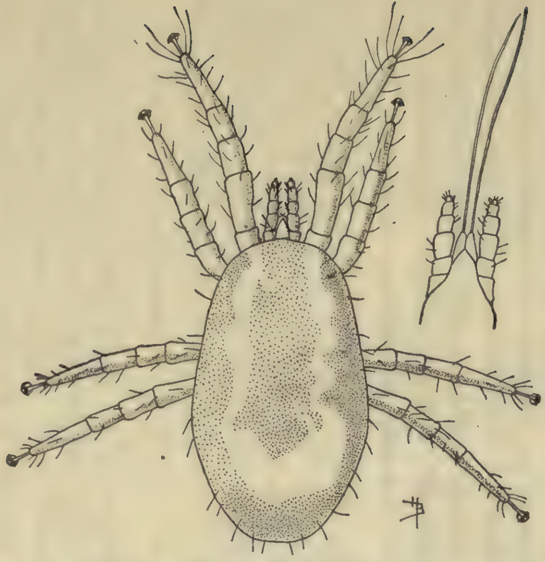

FIG. 3.—Female chicken mite before feeding, greatly enlarged. Mouth parts at right more highly magnified. (Original.)

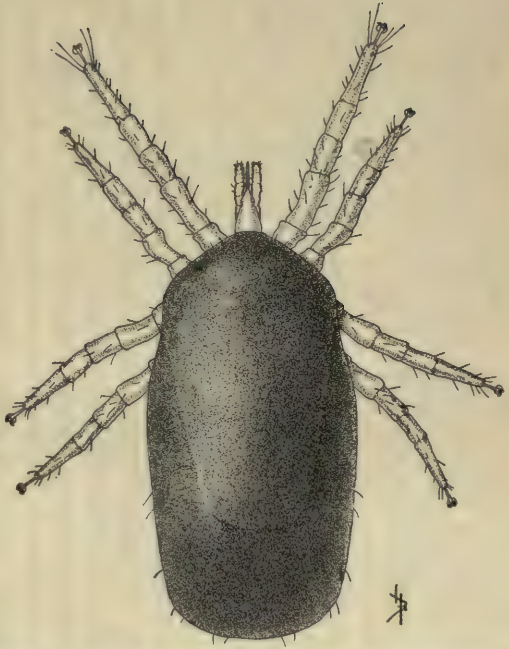

FIG. 4.—Female chicken mite after feeding. Greatly enlarged. (Original.)

The weather is never too hot for this mite to thrive, and development is most rapid in midsummer. In the Southern States the mites are not entirely dormant during the winter, but feed and develop when the temperature is not low. This is also true in the North in chicken houses that are heated. Where some development takes place throughout the year, and where a complete generation of mites is developed in a week's time, hordes of mites will be present in a poultry house within a comparatively short time if something is not done to destroy them.

LENGTH OF LIFE.

It is probable that in a poultry house once infested at least four months and probably five will be required before all of the mites will starve if the chickens are removed from the house. In tests made by the writers some mites were still alive after a period of 113 days, and since these individuals were collected from an infested house it is not unlikely that they had matured some time previously. The tests indicate that where the mites are supplied with a certain amount of moisture they will live longer than when kept under very dry conditions. This may account, in part at least, for the idea that mites are worse in damp and badly ventilated chicken houses.

HOSTS AND METHODS OF SPREAD.

Chicken mites do not feed to any great extent upon other hosts when chickens are at hand. They are carried about chiefly by the interchange of poultry and in crates and boxes in which fowls are shipped. No doubt clean premises sometimes are infested by mites carried on the clothing of people going from one chicken yard to another.

CONTROL.

Owing to the fact that mites feed during the night and secrete themselves in cracks and crevices during the day, their presence very often is overlooked until a very heavy infestation has developed. In such cases they should be attacked energetically. Although not hard to kill, the greatest obstacle is the difficulty of reaching them in their hiding places. Dust baths will not control them, as at most only the few which remain on the chickens during the daytime will be destroyed.

TREATMENT OF INFESTED CHICKEN HOUSES.

The first step necessary to destroy the mites is to get rid of the hiding places so far as possible. The roosts should be taken down and all unnecessary boards and boxes removed. In heavily infested houses the mites are to be found in all parts of the building, including the roof. Where they are less numerous the infestations usually are confined to the roosts and nests and the walls immediately adjacent. For small coops a hand atomizer will suffice for applying insecticides as sprays, but for larger houses a bucket pump, knapsack sprayer, or barrel pump is desirable. A rather coarse spray should be applied from all angles and thoroughly driven into the cracks. The floor also should be treated, as many mites fall to the floor when the roosts are being removed.

In tests conducted during the last two years a considerable number of materials used as sprays have proved effective. One of the so-called wood preservers [1] was found immediately effective, and its killing or repelling power lasts for months. As this material is rather expensive (about $1 per gallon), and is too heavy to spray well, it is advisable to reduce it with equal parts of kerosene.

Crude petroleum is almost as effective, retains its killing power for several weeks, and in most localities it is very cheap. It will spray better if thinned with one part of kerosene to four parts of crude oil.

Both of these materials often contain foreign particles which should be strained out before the spraying is begun. It has been found that one thorough application of either of these materials will completely eradicate the mites from an infested chicken house, but ordinarily it is advisable to make a second application a month after the first, and in some cases a third treatment is required. These subsequent applications may be made with a brush, using the materials pure and covering only the roosts, their supports, the walls adjoining, and the nests if they are infested. This method of application is effective for the first treatment also if the houses are not heavily infested. Poultry should be kept out of the treated buildings until the material is well dried into the wood.

Pure kerosene and kerosene emulsion in double the strength ordinarily applied to plants will destroy all mites hit, but these substances have not body enough to destroy those mites which are in more protected situations, and several applications at 10-day intervals are needed to destroy all the mites.

Arsenical dip, such as is used to destroy cattle ticks, has been found fairly satisfactory for use against chicken mites. Several applications are required to eradicate the mites from poultry houses. In regions where cattle dipping is practised and this solution is readily available, it is perhaps the most convenient and cheapest material to use. Of course due care should be taken to avoid the accidental poisoning of the fowls. The standard coal-tar stock dips, used in solutions slightly stronger than are recommended on the cans, will destroy all mites reached by the spray, and in addition their germ-destroying properties are a desirable feature.

---

[1] The product referred to is employed extensively for the preservation of posts and other timbers set in the ground, and consists of certain coal-tar products known as anthracene oil, with zinc chlorid added. Crude carbolic acid is quite effective, but has less body and hence does not last long.

In tests made by the writers lime-sulphur solutions such as are used against scale insects proved much less effective than the insecticides already mentioned. Standard indoor whitewash[1] with 5 per cent of crude carbolic acid or cresol added gives good results, although not equal to those obtained by the use of crude oil or the wood preserver mentioned. Dry sulphur or lime will not control this mite.

With any insecticide the results will depend largely on the thoroughness of the application.

ROOSTS AND NESTS.

After the first spraying it is advisable to put in new roosts if the old ones furnish many hiding places for mites. The roosts should never be nailed to the side of the building but arranged so as to be easily removable. A convenient form of roost is shown in figure 5. The supports for the roost poles should consist of two 2 by 4's on edge in a horizontal position. The ends of these rest in notches cut in the ends of four uprights made of 2 by 6's and driven into the ground or nailed to the floor. The roosts should consist of smooth 1 by 3's or 2 by 2's, the ends resting in notches cut in the 2 by 4's. If the notches fit the poles closely it is unnecessary to nail the latter. The roosts thus are removed easily when the chicken house is to be cleaned, and a coat of one of the mite destroyers mentioned can be applied to the ends of the roosts occasionally. If dropping boards are used they can be made to fit up to the four posts. In larger houses the horizontal 2 by 4's may be fastened to the back wall with hooks or certain types of screen hangers.

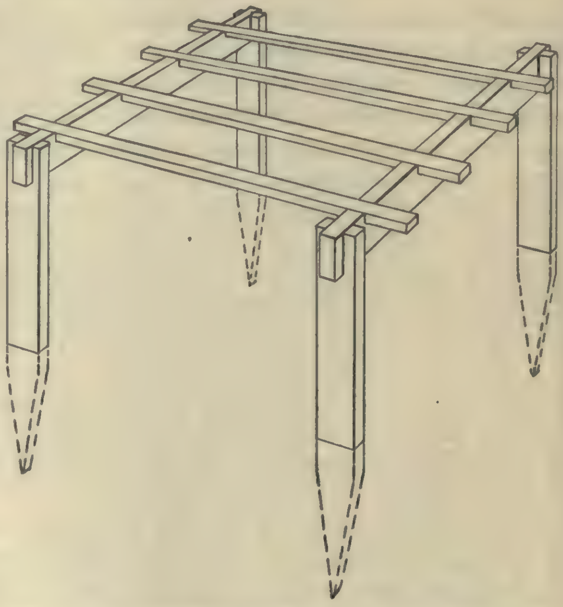

FIG. 5.—Chicken roost, suggesting method of making treatment for mites easy. (Original.)

Another method of constructing the roosts, which is especially applicable to the Southwestern States where the chicken tick occurs, is to suspend a frame from the ceiling on baling wire and place the roosts across this frame. None of the structure should be allowed to come in contact with the walls, and there is then little opportunity for mites to reach the chickens. The underside of the roosts must be watched, however, to see that mites have not been introduced accidentally, as they have been known to breed on such roosts until present in considerable numbers.

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[1] Methods of making whitewashes are discussed in Farmers' Bulletin 474 of the Department of Agriculture.

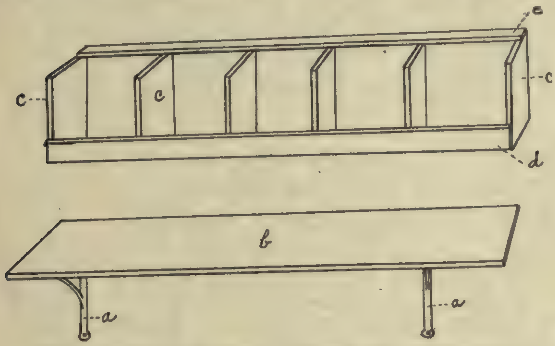

FIG. 6.—Simple nest boxes. (Herrick, with modifications.)

If convenient, the nests should be entirely apart from the roosting quarters. They may consist of boxes, which are easily handled, cleaned, or, if infested, destroyed. A series of nests made of boards is not objectionable if placed on a framework free from the walls of the henhouse and easily removable for cleaning. The simple arrangement devised by Prof. Herrick and illustrated in figure 6 may be used. Wooden or iron brackets (*a*) are fastened to the wall and upon these is laid a 12-inch board (*b*) which forms the bottom of the nests. The back of the nests is formed by the wall, and the partitions are made by cutting a 12-inch board into pieces 12 inches long (*c*) held upright by a 1 by 3 (*e*) nailed on top even with the back edges and a similar strip (*d*) nailed along the front at the bottom. The partitions and the bottom can be readily lifted off and thoroughly cleaned and the wall behind treated.

Great care should be taken to keep nests occupied by sitting hens free from mites. It is hard to work effectively against the mites when many hens are brooding; moreover, oil used freely about the house at that time may soil the eggs and prevent successful hatching. Infested quarters, therefore, should be treated thoroughly in the late winter before hens are set, so as to start them in nests which are absolutely clean. Beneath the straw of the nest a layer of lime and sulphur will tend to prevent mite breeding, and the entire nest may be dusted occasionally with pyrethrum. Broken eggs and the straw soiled by them should be removed promptly, as they tend to attract mites.

When poultry are to be transferred to new quarters it is desirable that they be kept three days and nights in a pen so that the mites will leave them before their introduction into the new building. The roosts in the new building and in the quarantine cage should be treated in order that any mites which have left the fowls may be destroyed.

SCALY-LEG MITE, DEPLUMING MITE, AND OTHER MITES.

Two species of itch mites attack fowls, one of which [1] is the cause of scaly leg. While this mite commonly remains on the feet, burrowing through the scales and causing their enlargement, it also attacks the comb and the neck. A crust of loose tissue is formed above the burrows, and intense itching results from this mining habit. When scaly leg is left untreated the feet often become badly distorted, and in some cases the fowl can scarcely walk or get up to the perch. Sometimes terminal joints of the toes are lost. As the mites are transferred from one bird to another, scaly-leg fowls should be treated promptly and should not be introduced among clean birds. Wood preserver or crude petroleum used on the roosts doubtless will aid in preventing the spread of the scaly-leg mite from one fowl to another. Applying crude petroleum to the legs with a brush or dipping the legs into this oil is very effective. One application usually is sufficient, but if the scales are not largely shed off after a lapse of 30 days the treatment may be repeated. Kerosene oil is applied by some farmers in the same way, but is less effective than crude oil. In using either, care should be taken not to get the oil on the upper part of the leg or on the feathers. A less severe but more laborious treatment consists of soaking the feet in warm soapsuds until the scales are loosened and then greasing the feet and legs with sulphur and lard, or lard containing 6 per cent crude carbolic acid.

The other itch mite,[2] commonly called the depluming mite, is a very small creature which burrows into the skin near the base of the feathers. The intense itching sometimes causes the fowls to pull their feathers until they are almost naked. Repeated applications of sulphur ointment should destroy these mites.

There are two other species of small soft-bodied mites sometimes found on poultry. One of these [3] bores into the skin. The other,[4] which has been found in several places in this country, occurs in the air passages, lungs, liver, and other internal organs of chickens and turkeys. Serious injury probably is not caused by these mites except when they are present in large numbers, when breathing may be hindered. Another small mite [5] sometimes feeds on the feathers of fowls but causes no apparent injury. Still another species [6] has recently been found by the writers in great numbers along the grooves on the under side of the shaft of the wing feathers of turkeys in Texas and Louisiana. Associated with this, but apparently in very small numbers, another mite [7] was taken. Neither of these caused any apparent injury to the host. Several other kinds of mites are found on various birds, as well as domestic fowls, but these are of little or no importance as parasites.

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[1] Known scientifically as *Cnemidocoptes mutans* Robin. [2] *Cnemidocoptes gallinae* Railliet. [3] *Laminosioptes cysticola* Vizioli. [4] *Cytoleichus nudus* Vizioli. [5] *Rivoltasia bifurcata* Rivolta. [6] *Freyana chanayi* Trouessart. [7] *Megninia cubitalis* Megnin.

CHIGGERS ("RED BUGS" OR HARVEST MITES).

The chiggers which attack chickens are the same minute red mites which attack man. They are the first stage of a large red mite, which when mature is entirely harmless. Normally these immature mites are parasitic upon insects. They are often very widely distributed in fields and thus readily picked up by chickens. They attach themselves to the skin in groups beneath the wings and on the breast and neck. The injury is most severe among young chickens, although grown fowls occasionally are annoyed to some extent Young chickens which have a free range, especially if it extends into lowlands and under trees, are very susceptible to attack. The infested chickens become droopy, emaciated, soon refuse to eat, and if exposure to the mites is continued a considerable mortality is likely to result. Intense irritation is set up, and abscesses are formed at the points where the clusters of mites are feeding. These abscesses sometimes are one-third of an inch in diameter and surrounded by a greater inflamed area. Suppuration takes place beneath the skin, and swelling around the clusters of mites causes the formation of a considerable cavity at the center where the mites are attached.

In the South and in the Central States, where chiggers are numerous, probably the best plan is to keep young chickens during the summer from ranging where these mites are likely to occur. If chickens are hatched very early in the spring it is likely that they will escape chiggers more or less completely. When the chickens do become infested the application of sulphur ointment or kerosene and lard will destroy them. If extensive suppuration has taken place the scab should be removed and the area washed with a 4 per cent carbolic-acid solution. Occasional light dusting of chickens with flowers of sulphur doubtless will keep these "red bugs" off, and where fenced range is infested the application of sulphur at the rate of 50 pounds per acre with a dust blower would keep them in control.[1]

LICE.

LICE ON CHICKENS.

All poultry lice or bird lice have stout cutting or biting mouth parts which distinguish them from the sucking lice of cattle and other domestic animals. Unlike the mites, lice remain on the hosts constantly. More than 40 species of lice are found on the various domestic fowls. Some species are found on one host only, while other kinds may attack a number of fowls. Chickens are infested by more kinds of lice than any other domestic fowl. Seven species are very commonly found on chickens in the United States, four or five on pigeons, two or three each on geese and ducks, three on turkeys, and several each on guinea fowl and peafowl.

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[1] Further information regarding harvest mites or red bugs may be had from Farmers' Bulletin 671, which may be obtained on application to the Secretary of Agriculture, Washington, D. C.

All these lice are adapted to the conditions under which they live. They have a flattened form and are fitted with various spines and peculiarly modified legs which assist them in moving about through the feathers. Certain species which remain on the larger feathers have a very narrow, elongate form which utilizes the protection afforded by the grooves between the barbs of the feathers. In fact, poultry lice show a wide divergence in size, shape, and spiny armature.

FOOD HABITS AND INJURIOUSNESS.

Poultry lice are not fitted for sucking blood. They feed on portions of the feathers or on scales from the skin, and their presence in any considerable numbers is responsible for serious injury.

In the Southern States the loss due to lice probably is greatest among young chickens. Chickens hatched after April 1 and brooded by hens experience a high mortality, much of which appears to be due directly or indirectly to lice. Early chickens also are sometimes affected. The lice often leave the hens and pass to the chickens before these become dry after emerging from the shell.

The first symptoms of lice infestation usually are droopiness, lowered wings, and ruffled feathers. Diarrhea follows, and the chickens then often die in a few days, or, when older, sometimes fall a prey to various diseases. Grown fowls sometimes may be very heavily infested with lice without showing any ill effects, but in such cases the egg yield is likely to decrease. In other cases the fowls may lose weight and sometimes die as a result of the lice or succumb to some of the common chicken maladies.

Turkeys suffer to a considerable extent when young, and no doubt poults frequently are killed by gross infestation. Older birds do not seem to be so badly affected. This is also true of ducks and geese. In general, these fowls are less heavily infested with lice than chickens.

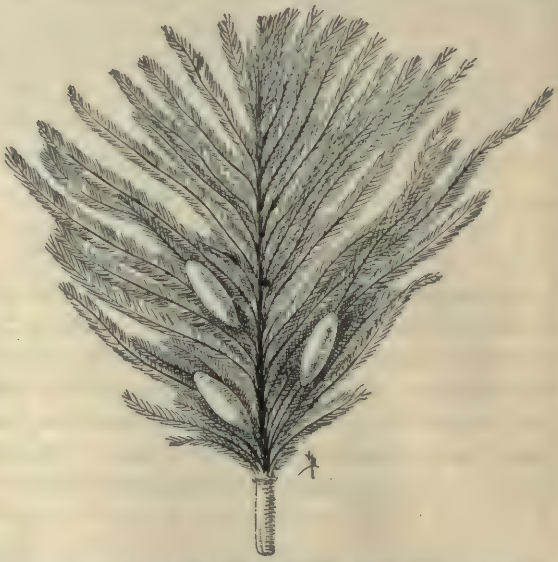

FIG. 7.—Eggs of the head louse (*Lipeurus heterographus*) on feather. Greatly enlarged. (Original.)

KINDS OF LICE ON CHICKENS.

The seven different species of lice common on hens are spoken of as body lice, head lice, and feather lice, according to the usual places in which they are found, but since the different species intermingle to a considerable extent, it is not possible to separate them absolutely on this basis. The writers have observed that the relative number of lice of the different species varies much in different flocks in the same neighborhood, and even in the same flock some chickens often have one species predominating, while others have another. Usually three or more species are to be found on an infested fowl.

THE HEAD LOUSE OF CHICKENS.[1]

This species is primarily a head louse, although occasionally found on the neck and elsewhere. It is undoubtedly the most injurious species to young chickens, as many of the other forms which are serious annoyers of grown poultry do not thrive well in the down on chicks. It is a dark grayish species nearly one-tenth of an inch in length, and may be found on the top or back of the head, behind the ears, or beneath the bill. Usually it is located close to the skin with its head very close to or against the skin of the chicken, the body extending away from the skin on the down or along the feathers. The eggs are deposited singly on the down or small feathers about the head. Eggs attached to a small feather are shown in figure 7. These hatch in four or five days into minute semitransparent lice which resemble the adult in shape. After molting the skin several times, and in the meantime increasing in size and becoming darker in color, the lice reach the adult stage in about 17 to 20 days. The male of this species is shown in figure 8.

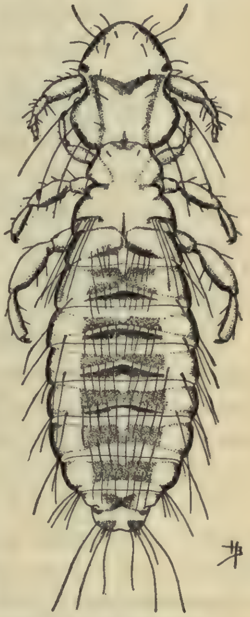

FIG. 8.—Head louse: Male, top view. Greatly enlarged. (Original.)

Despite the fact that this louse confines its attack principally to the head, it passes readily from one chicken to another and from the mother to her young. This is the species against which the poultryman must guard his young chickens. The treatment recommended for various lice (p. 22) is satisfactory for this species. It is essential that the applications be made to the regions about the head to destroy it on grown fowls, and on young chickens this is the only region which requires attention. After young chicks are fairly well feathered the head louse decreases in number, probably because conditions are less favorable for breeding and because the older chickens scratch the infested parts more vigorously. The number of head lice may increase again after the chickens become adult.

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[1] *Lipeurus heterographus* Nitzsch.

THE BODY LOUSE OF CHICKENS.[1]

The common name "body louse" is aptly applied to this species, and refers to its habit of remaining on the skin of the fowl rather than on the feathers. It does not always confine itself to the body, sometimes being taken on the head, neck and legs. It favors those portions of the skin which are not densely feathered. On chickens it is partial to the region just below the vent, but in heavy infestations it is abundant on the breast, under the wings, on the back, and also on the head, neck, and thighs. When the feathers are parted it is seen running rapidly upon the skin to seek protection. With young chickens it is more abundant on the back than around the vent.

This louse is rather large and robust, straw yellow in color, with some dark spots due to food within the digestive tract. The two sexes are shown in figures 9 and 10.

The body louse is probably the most injurious species on grown chickens, but it also infests young fowls, sometimes seriously. As it remains on the skin of the host, irritation is kept up constantly. Often a marked reddening of the skin of the fowl in the regions most heavily infested results, and in some cases scabs and blood clots are formed.

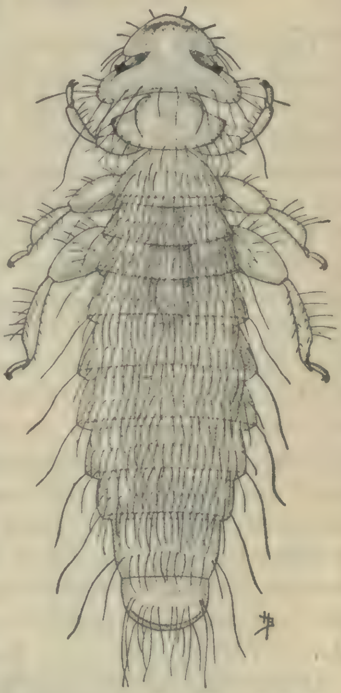

FIG. 9.—Body louse (*Menopon biseriatum*): Male, top view. Greatly enlarged. (Original.)

The eggs are deposited in clusters on the base of the feathers, usually being attached to the lowest barbs along the shaft. They are most abundant on the small feathers below the vent, where the masses of eggs sometimes become very large—fully half an inch in length. As the lice continually add eggs, the masses are extremely large when seen several months after molting. In the case of young fowls the eggs are often deposited in numbers on down or small feathers and on hairs about the head and throat. A mass of eggs of this species is shown in figure 11.

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[1] *Menopon biseriatum* Piaget.

The eggs hatch in about a week, and the adult stage is reached from 17 to 20 days after the eggs are deposited. This louse has a short period of growth both in summer and in winter; hence fowls which are not actively fighting the louse become swarming with them in a very short time. Fortunately the heat of the body is necessary for the hatching of the eggs, and the lice themselves die in a very short time when off the fowl. For this reason little attention need be given to lice and eggs which are shed by the host during molting or at other times. This point, as well as methods of control, is discussed in later pages.

The body louse appears to pass readily from one fowl to another when they are closely associated. It also infests turkeys, upon which it multiplies to some extent, and it is said to occur on pigeons, but has not been found on them by the writers.

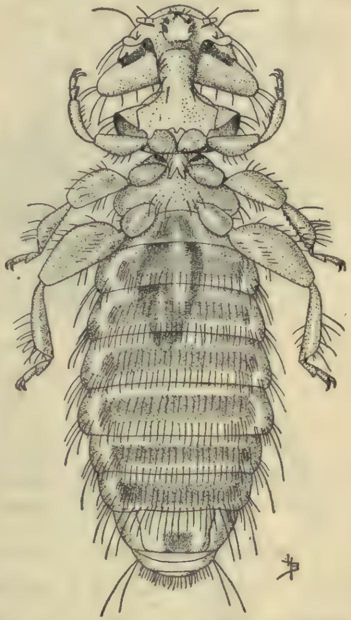

FIG. 10.—Body louse: Female, underside. Greatly enlarged. (Original.)

THE SHAFT LOUSE.[1]

The shaft louse is the species spoken of by most authors as the "small body louse," a name which does not fit the habits of the species. Normally, it occurs along the shaft of the feathers and does not remain on the body of the host for any length of time. The shaft louse is closely related to the large body louse and resembles it somewhat. It is smaller, rather lighter yellow in color, and somewhat less spiny. (See fig. 12.) The habits of the shaft louse will enable one to separate it readily from the large body louse. When the feathers on the back or breast are parted this louse will be seen running toward the body along the shaft of the feather. Sometimes as many as a dozen lice will be seen, one behind another, along the feather shaft.

Although this species is probably the most common found on chickens in various parts of the country, the writers consider it of much less importance than the body louse, chiefly because it stays on the feathers the greater part of the time and probably feeds exclusively on the barbs of the feathers and on scales along the shaft. It is not known to occur on young chickens. Seemingly the absence of feathers prevents the successful development of the species on young fowls.

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[1] *Menopon pallidum* Nitzsch.

The eggs are deposited singly at the base of the feathers, hidden between the main shaft and the after shaft. It appears that eggs of the shaft louse require more time for incubation than those of the head louse or the body louse, and the time required to reach maturity is also greater. The shaft louse appears to live much longer on feathers which have dropped from the host than any other species on domestic fowls.

Several kinds of domestic fowls harbor the shaft louse, but it has not been shown that they will breed successfully on fowls other than the chicken. It has been found on the guinea fowl and on turkeys and ducks closely associated with chickens.

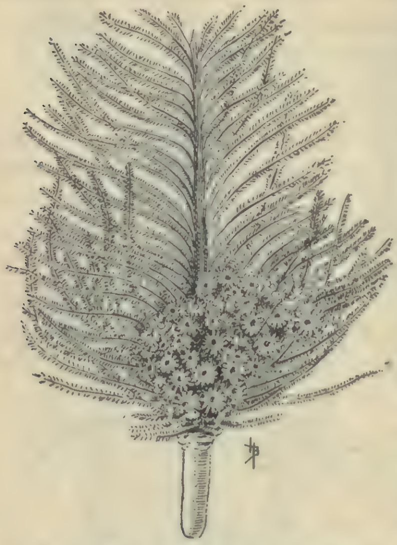

FIG. 11.—Mass of body louse eggs attached to feather. Greatly enlarged. (Original.)

THE WING LOUSE.[1]

This species has been called the "variable louse," but the variations are not apparent to the ordinary observer, and the writers suggest "wing louse" as a common name. This is the only species found commonly on the large wing feathers of chickens. It is seen at times also on the neck hackles, tail, and back feathers.

The wing louse, which is related to the head louse, is dark gray and has an elongate body. It is more slender than the head louse, however, and rather darker in color. Most easily seen on white fowls, it is found in all situations, but especially along the underside of the primary wing feathers. It is a sluggish species and often lies between the barbules of the feathers near the shaft without showing any life. The elongate white eggs are laid between the barbules of the large feathers.

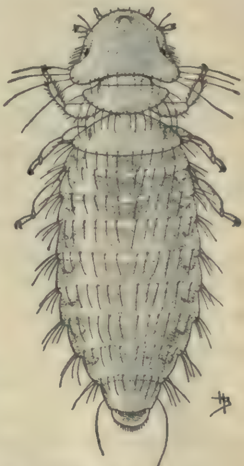

FIG. 12.—Shaft louse (*Menopon pallidum*): Female, top view. Greatly enlarged. (Original.)

OTHER LICE OF CHICKENS.

Three other species of lice are found more or less commonly on chickens. The species to which the writers have applied the common name of "fluff louse"[2] is very small but broad, pale in color, with a translucent appearance. It is common on fowls, but seldom abundant, and is of little importance. It is found on the fluff of the feathers on various parts of the bird, but is most abundant where the feathers are fluffiest. Usually it hangs to the loose barbs on these feathers some distance from the shaft and shows little activity.

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[1] *Lipeurus variabilis* Nitzsch.

[2] *Goniocotes hologaster* Nitzsch.

The large hen louse[1] is less abundant than the fluff louse. When present, it is easily recognized by its very large size and striking appearance. It is nearly an eighth of an inch in length and very broad in proportion, as shown in figure 13. The color is smoky gray to almost black, with darker marks on the sides of the abdomen. It occurs on the feathers on various parts of the chicken's body and is remarkably agile for its size. Some call it the "blue bug," hence it has become confused in certain instances with the chicken tick, for which the name blue bug is generally used.

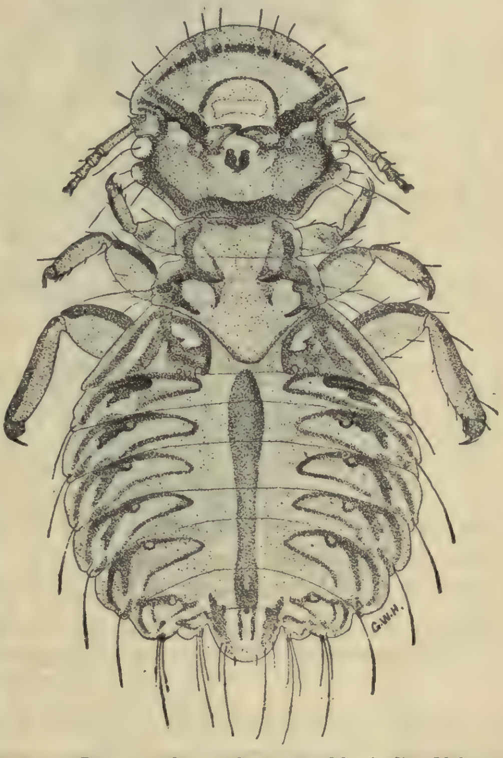

FIG. 13.—Large hen louse (*Goniocotes abdominalis*): Male, top view. Greatly enlarged. (Herrick.)

The brown chicken louse[2] has not been reported to occur in America heretofore. The writers have taken it in several instances on chickens in the vicinity of Dallas, Tex., and Orlando, Fla. This indicates its presence in much of the South. It is somewhat smaller than the large hen louse and reddish brown in color. It is found on the feathers of the body. None of the three species last discussed has been taken by the authors on young chickens.

LICE ON TURKEYS.

Four species of lice are commonly found on turkeys in this country. One of these, which occurs particularly on turkeys associated with chickens, is the common body louse of chickens. The writers have not found this species in great numbers on turkeys, but it sometimes becomes sufficiently abundant to cause considerable irritation and doubtless is injurious both to the grown fowls and to the young.

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[1] *Goniocotes abdominalis* Piaget.

[2] *Goniodes dissimilis* Nitzsch.

The shaft louse of chickens also has been found on turkeys, but probably does not breed on that host. The other two species seem to be native to the turkey, probably existing on this fowl in the wild state. The large turkey louse[1] (fig. 14) probably is most abundant. It occurs on the feathers on various parts of the body, especially on the neck and breast. The slender turkey louse is a species of good size, though rather elongate, resembling in shape the head louse of chickens. Normally neither of these species is excessively abundant, but on crippled or unthrifty turkeys they may cause serious annoyance and undoubtedly they are injurious to poults.

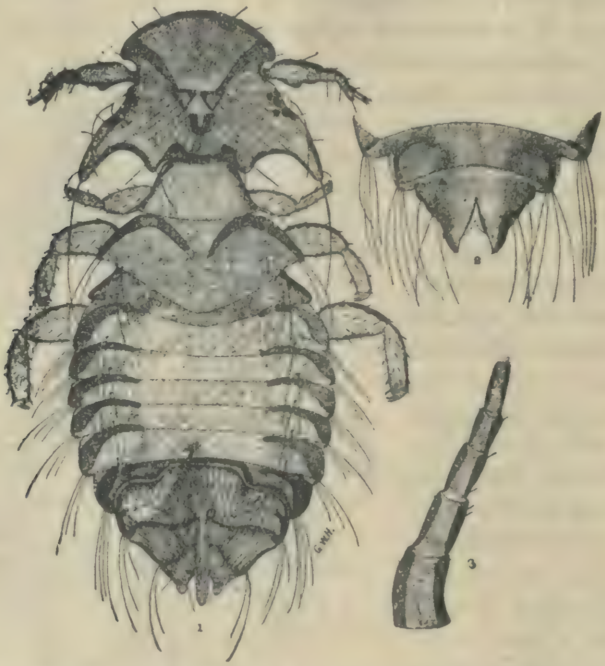

FIG. 14.—Large turkey louse (*Goniodes stylifer*): *1*, Male, top view; *2*, tip of abdomen of female; *3*, antenna of female. All greatly enlarged. (Herrick.)

For remedial measures see pages 19–26.

LICE ON GEESE AND DUCKS.

While considerable numbers of lice are found on domestic geese and ducks, they seldom become sufficiently numerous to cause noticeable injury. One of these species[2] is quite common on ducks throughout the country, and a variety of this same species is to be found on the goose. A slender species[3] has been found by the writers rather commonly on the duck in the vicinity of Dallas, Tex., and in other parts of the United States. Another louse similar in form, but which appears to be new to science, has been collected on these hosts in Mississippi. Both of these species inhabit the wing feathers and are often very numerous at the base of the large feathers of the wing. Young ducks which have been hatched by hens are sometimes much annoyed by the head louse, which attacks them in the same way as it does young chickens.

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[1] *Goniodes stylifer* Nitzsch.

[2] Known scientifically as *Docophorus icterodes* Nitzsch.

[3] *Lipeurus temporalis* Nitzsch.

The same control measures recommended for chicken lice will destroy these insects on ducks and geese.

PIGEON LICE.

Considerable annoyance to pigeons has been reported by poultrymen in different parts of the country. While a number of species are reported from pigeons, most of the trouble seems to be due to the slender pigeon louse[1] and the broad pigeon louse.[2] The former sometimes occurs in great numbers, attacking both the old birds and the partially feathered squabs.

For measures of control see the discussion of this subject in subsequent pages.

LICE OF THE GUINEA FOWL AND PEAFOWL.

The guinea fowl and peafowl are both subject to the attack of several species of lice. Most of these are of kinds different from those found on the common chicken and other domestic fowls, but the guinea fowl has been found to become infested with four of the species found on the chicken. It does not appear that either of these hosts is materially injured by lice, but it is necessary to bear in mind the risk in allowing guinea fowl to remain untreated when eradicating lice from other poultry on the same farm.

CONTROL OF POULTRY LICE.

It has been generally felt that poultry lice are more or less a necessary evil and that the best that can be expected is to keep them in control by repeated treatment. A few have attempted, with varying degrees of success, to start with clean premises and clean fowls and keep them free from vermin. This is most feasible in the case of persons going into the poultry business on a rather extensive scale and with entirely new equipment (see page 26). For the average farmer and the poultryman already established the situation has resolved itself largely into a fight against the various pests already present.

There is no fundamental reason why a flock should not be entirely freed from lice and maintained in this condition. Reinfestation comes principally from stray fowls which gain access to the poultry yards and from purchased stock added to the flock. Stray fowls can not always be excluded, but in the case of added stock it is advisable to treat all chickens, old or young, when they are first brought on the premises.

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[1] *Lipeurus baculus* Nitzsch.

[2] *Goniocotes compar* Nitzsch.

The time of year for starting a campaign against lice is another point to be considered. The writers would favor the treatment of the entire flock during the late summer or early fall. At this time of the year weather conditions usually are favorable to dipping, most of the young fowls are well matured, and much of the superfluous stock has been disposed of, so that there are fewer birds to treat. Since there is very little danger of reinfestation from lice on molted feathers, the question of avoiding the molting period is not a serious one, yet, if the treatment can precede molting it probably would be better.

If the fall treatment has been neglected it is imperative that the flock be cleaned of lice before brooding time in the spring. Usually this would mean that the dusting method would have to be followed on account of adverse weather conditions. Treating the birds at this time will insure their vigor as well as undisturbed brooding, which is necessary to successful hatching, and, what is more important, the infestation of the young chickens will be avoided. Although lice normally stay upon the host continuously and do not have the habit of hiding away in cracks about buildings, yet the poultry houses and runs should be well disinfected occasionally, especially as action against mites is necessary if these are present. It is well to make this general clean-up at the time the flock is treated for lice. This minimizes any danger of reinfestation.

On large poultry farms the complete eradication of lice is often complicated by inability to control the fowls. When proper pen construction is at hand, it is possible to treat a pen or two a day until the entire flock is covered. The more rapidly treatment progresses the better, of course, and great care should be taken to avoid the escape of fowls from infested to uninfested pens.

SODIUM FLUORID EFFECTIVE AGAINST ALL LICE.

The writers have tested a number of the materials most generally advocated for lice destruction and several new compounds which it was thought might be effective. In this series of tests nothing else was found to be as satisfactory as sodium fluorid. The experiments have demonstrated that this chemical is exceedingly poisonous to all species of chicken lice. It kills both adults and young, including the young which emerge from the eggs present at the time of treatment.

Sodium fluorid can be obtained in two forms, known as commercial and as chemically pure. Both of these are in a dry state, the former being a dry powder and the latter consisting of small crystals somewhat lumpy. While the chemically pure material is effective, it is not as easily applied by the dusting method as the more finely powdered commercial form, and, furthermore, it is higher in price. The commercial grade should contain 90 to 98 per cent sodium fluorid.

This material is the sodium salt of the chemical element known as fluorin and hence is a compound very similar to ordinary table salt, which is known chemically as sodium chlorid. In asking for sodium fluorid it is therefore important that the name "fluorid" be carefully stated to the druggist. Up to this time the demand for the material has been very limited. Prior to the work of the writers its only known insecticidal use was against cockroaches, for which it has been demonstrated to be very effective. Owing to this limited demand the material is not ordinarily found in drug stores. Druggists, however, can obtain it readily from manufacturing chemists in the larger centers, and with demand it will be carried in stock by many local dealers. The commercial sodium fluorid at present prices should be retailed at from 30 to 60 cents per pound, the price varying somewhat with the amount ordered by the druggist and the distance from the chemical manufacturing centers.

Sodium fluorid in a dry state does not deteriorate quickly. It should be kept in a dry place either in bottles with stoppers or in closely covered cans. In this condition it will remain active indefinitely.

METHODS OF APPLICATION.

In treating poultry with sodium fluorid, *if proper methods are followed, a remarkable degree of control is obtained. One application of sodium fluorid to all fowls on given premises will completely destroy all lice present.* It is essential to make sure that the treatment is thorough and that every fowl is treated, for if one infested chicken escapes it will in a short time reinfest the entire flock and thus make it necessary to do the work over at a considerable loss of time and money.

Sodium fluorid may be applied in two forms, as a dust and as a dip. In using either form the first step is to see that all fowls are shut in the poultry house or placed in coops prior to beginning treatment.

DUSTING.

The action of sodium fluorid when applied in dust form is comparatively slow; hence, if fowls are examined the day following treatment, or even two or three days later, some lice may be found. The material persists, however, and after four or five days all lice disappear. Apparently the hatching of the eggs is not prevented, but the young lice find sufficient material present in the feathers upon emerging from the eggs to destroy all of them.

For complete destruction of lice it is essential to place small amounts of the material on different parts of the infested birds. Contrary to the usual belief, all species of lice do not migrate freely from one

605

part of the bird to another, hence the material must be well distributed to bring it in contact with all lice present.

The writers have found what they term the "pinch method" to be entirely effective against all lice and to have the advantage of economy of time and material. When applying the material by this method (see illustration on title page) it is placed on a table in an open vessel, and the fowl is held by the legs or wings with one hand, while with the other hand a small pinch of the chemical is placed among the feathers next to the skin about as follows: One pinch on the head, one on the neck, two on the back, one on the breast, one below the vent, one on the tail, one on either thigh, and one scattered on the underside of each wing when spread. Each pinch can be distributed somewhat by pushing the thumb and fingers among the feathers as the material is released. It is advisable when dusting to hold the chicken over a large shallow pan, as in this way the small amount of material ordinarily lost is recovered.

The material may be applied by means of a shaker, but this method has some disadvantages as compared with the pinch method. Small nail holes are punched in the bottom of a can, which is provided with a close-fitting lid on the other end. The material is then shaken into the feathers with one hand, while the feathers are opened with the other. This necessitates the presence of a second person to hold and turn the fowl. When this method is followed the amount of sodium fluorid used may be reduced by adding four parts of some finely powdered material, such as road dust or flour, to each part of the chemical. If the material is employed alone, somewhat more of it is used than by the pinch method, and more or less dust floats in the air, which causes irritation of the throat and nose. This can be avoided largely if the operators wear dust guards over the nose or keep pieces of wet cloth over the nose and mouth.

Although the writers have not applied this material with a dusting machine or revolving barrel, they are of the opinion that this would not be thorough, might bruise the fowls, and would be irritating to the air passages of the birds.

For lice on young chickens, young turkeys, and in fact all newly hatched fowls the application of sodium fluorid in the dust form is recommended, rather than by dipping. This applies also to sick fowls. While the writers have not tried dipping against lice on pigeons, the dusting method has been found effective.

DIPPING.

There seems to be a general sentiment among poultry raisers against the practice of dipping fowls. This is probably partially on account of the fact that the dips tried have been of an oily or caustic nature and have tended to soil the feathers and in some cases injure the skin of the fowl and give the feathers a thorough wetting.

The experience of the writers does not justify this aversion when dipping in a sodium-fluorid solution. It may be said that in general the dipping method is most applicable to the Southern States and to summer treatments in the north. The first requisite is a rather warm sunny day so that the fowls will dry quickly. Windy weather should be avoided. In dipping fowls as described below, the feathers do not get thoroughly wet, and if the operation is finished an hour before sundown the fowls will become thoroughly dry before going to roost. In rather extensive tests of this method the writers have observed no ill effect whatever from the dipping. As compared with dusting, this method has an advantage in that it reduces considerably the cost of materials, is more rapidly done, and the discomfiture to the operator is avoided. It is just as effective as dusting.

The lice die much more quickly following dipping than when sodium fluorid is applied in dust form. It appears that all those which are touched by the liquid die very promptly, and the others succumb in a few hours.

In using the dipping method all that is necessary is a supply of tepid water and a tub. If two persons are to dip at the same time it is advisable to use a large tub. The water should be measured into the tub and three-fourths to 1 ounce of commercial or two-thirds of an ounce of chemically pure sodium fluorid added to each gallon of water. It is readily dissolved by stirring. The tub should be filled to within 6 or 8 inches of the top, and as the amount of solution is lowered through dipping numbers of fowls, water with the proper proportion of sodium fluorid dissolved should be added from time to time. In dipping the fowls it is best to hold the wings over the back with the left hand and quickly submerge the fowl in the solution, leaving the head out while the feathers are thoroughly ruffled with the other hand so as to allow the solution to penetrate to the skin on different parts of the bird. The head is then ducked once or twice, the bird is lifted out of the bath and allowed to drain a few seconds and is then released. The total time required for an individual fowl is from 30 to 45 seconds.

EFFECT OF SODIUM FLUORID ON FOWLS AND MAN.

Fortunately this compound is very destructive to lice without producing any ill effects on the chickens. No skin irritation or injury to the condition of the feathers has been observed in the large number of domestic fowls used in experimental work, when either the dusting or the dipping method was used. In dusting fowls there is occasionally some temporary irritation of the air passages, as evidenced by labored breathing and sneezing. This effect is not noticeable a few minutes after treatment.

Where some of the sodium fluorid in the dust form reaches the body of the operator and is allowed to remain for a number of hours, as may be the case in dusting several hundred fowls, local irritation and burning may occur on tender portions of the skin. In dusting large flocks it is therefore advisable to do the dusting on a table rather than to hold the fowls between the knees as is sometimes done. The solution does not injure the hands, even when dipping is continued for a number of hours, except in cases where sores are present which may become slightly irritated.

Precaution should be taken not to allow sodium-fluorid solution to remain in galvanized vessels any great length of time. In fact, it is best not to keep it over night in tubs or galvanized containers, as it will injure them.

COST OF APPLICATION.

One pound of commercial sodium fluorid, when applied by the "pinch method," will treat approximately 100 hens; thus at a cost of 40 cents per pound the expense for material will average less than one-half cent per fowl. It has been found by actual practice in treating several hundred fowls that an average of from two to three minutes is required for treating each fowl, one man doing the work. This includes the time necessary for catching the birds as well as dusting them. The dusting itself occupies about one to two minutes. Of course, the time involved in catching them would vary in every individual instance according to conditions. Using the above figures as a basis, and figuring a man's time at 20 cents per hour, it would cost approximately $1.25 to treat 100 fowls by the pinch method.

In treating with the dust can the amount of material is usually double and the average time per bird is somewhat increased.

By the dipping method the amount of the material is considerably reduced, especially if large flocks are to be treated at one time. Over 800 fowls have been dipped at one time, using on the average 5.2 ounces of sodium fluorid to 100 fowls, which at the same figure would cost 13 cents. The labor involved is also thus reduced. The average time for catching and dipping the birds was about one and three-fourths minutes per fowl, one man working. This makes a cost for labor, as above computed, of about 58 cents per hundred fowls and a total cost for material and labor of about 71 cents. This reduces the cost so that it is within the reach of every one, especially when it is considered that ordinarily much time is occupied in fighting lice without accomplishing that complete destruction which would result from a single treatment as above outlined.

OTHER REMEDIES FOR LICE.

While the use of sodium fluorid is advised in all cases, it may be stated that one application of flowers of sulphur when applied thoroughly in dust form has been found to destroy all stages of several species of lice experimented with. In a few instances, however, some lice remained on the fowls after treatment. This was attributed to the difficulty of getting the dust over every portion of the fowl, but at the same time it shows that exceedingly thorough and careful application of sulphur is required to secure complete destruction. About four days are required for the fowls to be freed of living lice. The ready availability of flowers of sulphur and its comparatively low cost per pound tend to recommend it for this use. Furthermore, it is not disagreeable to handle.

A number of poultry raisers, however, have stated that injury to the fowls sometimes results from the use of sulphur, although the writers have seen no injury further than a very slight scaling of the skin following treatment. It is possible that the injury observed by some was due to mixing the sulphur with grease or other substance. To accomplish complete destruction the writers have found it necessary to use considerable quantities of sulphur, averaging about 6 pounds per hundred fowls, which at 10 cents per pound would make a cost of 60 cents for the material. The expense of application would be about one-half greater than that given for the use of sodium fluorid by the pinch method, as it is necessary to apply the sulphur with a dust can. The total expense would therefore be greater than by using sodium fluorid by the pinch or the dipping method.

The writers have found also that dipping fowls in a soap solution made by dissolving 1 ounce of laundry soap in a gallon of water will destroy all lice present, but a second dipping 10 days later is necessary in order to destroy the lice that have hatched from eggs which are not killed by the treatment. This soap solution causes a complete wetting of the feathers, and hence there is no doubt danger of producing colds when the weather is unfavorable. It should be used only during favorable weather.

A great number of remedies are in general use in this country, only a few of which can be mentioned here. A mixture of crude carbolic acid, gasoline, and plaster of Paris is quite effective in reducing the number of lice, but experiments have shown that at least two and perhaps more applications are necessary to destroy all lice.

Mercurial ointment or blue ointment is also advised. It has been found that the use of this material as recommended will greatly reduce the number of body lice but has little effect on the head and wing lice. When several times the amount usually recommended is applied to a number of places on a fowl it is quite effective, but the cost of the material and treatment is greater than in the case of sodium fluorid, the use of greasy material is objectionable and burns result.

A number of other compounds, many of which contain pyrethrum, are advocated. These also fail to accomplish complete destruction of the lice. For head lice on young chickens carbolated petrolatum applied in small quantities has been found quite satisfactory. Medicated nest eggs, said to control poultry lice, are on the market. For the most part these consist largely of naphthalene. While this material will destroy lice when applied generally to the fowl, it is markedly injurious to the hen's eggs as well as to the bird. If used in quantity, or if the medicated eggs are allowed to remain for a considerable length of time beneath a hen, she may die as a result.

SUPPLEMENTAL CONTROL MEASURES FOR ALL PESTS.

Chickens will not give adequate returns in eggs or growth when kept under insanitary conditions. The construction of the poultry house should receive first attention. Adequate air space, lighting, and ventilation should be provided, and the entire house should be cleaned out at frequent intervals. While these things can not be depended upon to control mites and lice, they aid the poultryman in determining when these pests are present, and, furthermore, the fowls are kept in vigorous condition, which in itself is conducive to the control of various pests. Diseased fowls, or those with malformed bills or feet, fall ready prey to lice, mites, and other insect pests. The suggestions given in previous pages for the construction of roosts and nest boxes should be followed, even though the buildings are new and otherwise properly arranged.

DUST BATHS.

While it is well to provide a good dust bath for chickens, it can not be depended upon for louse and mite control. It is far better to eradicate the pests completely. The main difficulty about depending upon dust baths for lice is that some fowls seldom dust themselves, and those which dust freely never free themselves completely. The dust bath should be kept under cover and may consist of fine road dust with coal ashes added.

A METHOD OF AVOIDING POULTRY PESTS.

It is possible for a prospective poultryman to avoid having to contend with most poultry parasites by selecting a site which is fairly well isolated from other poultry. It should be first securely fenced and new buildings and runs constructed. He should start with incubator chickens hatched on the premises and never bring any fowls on the place. Second-hand crates should not be brought on the farm unless carefully disinfected beforehand. The possibility of insects being carried from infested quarters on clothing, wagons, etc., should be kept in mind, as well as the possibility of their carriage by sparrows.

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Principal Household Insects of the United States with Chapter on Insects Affecting Dry Vegetable Foods. (Entomology Bulletin 4, n. s.) 1896. Price, 10 cents.
Notes on Mosquitoes of the United States Giving some Account of Their Structure and Biology, with Remarks on Remedies. (Entomology Bulletin 25.) 1900. Price, 10 cents.
Notes on Punkies. (Entomology Bulletin 64, pt. 3.) 1907. Price, 5 cents.
Information Concerning North American Fever Tick, with Notes on Other Species. (Entomology Bulletin 72.) 1907. Price, 15 cents.
Economic Loss to People of United States Through Insects that Carry Disease. (Entomology Bulletin 78.) 1909. Price, 10 cents.
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Rocky Mountain Spotted Fever Tick with Special Reference to Problem of Its Control in Bitter Root Valley in Montana. (Entomology Bulletin 105.) 1911. Price, 10 cents.
Life History and Bionomics of Some North American Ticks. (Entomology Bulletin 106.) 1912. Price, 30 cents.
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Predaceous Mite Proves Noxious to Man. (Entomology Circular 118.) 1910. Price, 5 cents.
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CLASSIFICATION OF AMERICAN UPLAND COTTON

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FARMERS' BULLETIN 802

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Markets and Rural Organization
CHARLES J. BRAND, Chief

Washington, D. C. **July, 1917**

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CLASSIFICATION OF AMERICAN UPLAND COTTON.[1]

CONTENTS.

	Page.
Introduction	3
Classification according to grade	4
Classification according to color	9
Classification according to length of staple	10
Classification according to character	12
Trade names and regional characteristics	14
Classifying by standards	18
Relative values of different classes	22
Comparison of the official cotton standards of the United States for grade with Liverpool standards	25
Classes and conditions of cotton untenderable on future contracts	26
Summary	28

INTRODUCTION.

The present method of grading cotton dates back to about 1800, when grade names were first used in Liverpool, England. Until recently, those engaged in the trade—that is, the cotton merchant, broker or factor, and the spinner—were practically the only persons who classified or graded cotton. The producer rarely knew the grade of his cotton or for what use it was best suited.

Very few outside of those actually engaged in the trade had the opportunity of acquiring such knowledge until within the last few years. At present, almost all of the agricultural schools of the Southern States have added cotton grading to their regular courses of study. The county agents of the United States Department of Agriculture in the cotton States have been supplied with practical forms of the Official Cotton Standards of the United States, and the growers are able to make use of these copies to a considerable extent.

Several years of experience are necessary to learn to classify all the grades and qualities of cotton, but the grower need not be familiar with all of the grades. Often it is enough if he knows three grades: Low Middling, Middling, and Good Middling, since this range of grades covers the bulk of the white cotton grown in an average season. By practicing with a full set of types for comparison, a knowledge of the other grades may be gained gradually. Such knowledge, coupled with information regarding the corresponding market prices would be very useful to the grower and ultimately encourage him to produce a better quality of cotton and to handle it with more care.

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[1] This is a revision of the U. S. Department of Agriculture Farmers' Bulletin 591, "The classification and grading of cotton," by D. E. Earle and W. S. Dean, which bulletin was written in 1914 before the passage of the U. S. cotton futures act, and was based on the permissive standards. See U. S. Department of Agriculture, Office of Markets and Rural Organization, Service and Regulatory Announcements Nos. 1, 6, and 10, for a discussion of the new Official Cotton Standards established and promulgated on December 15, 1914, and reestablished August 12, 1916.

NOTE.—This bulletin should be of interest to cotton growers and ginners, agricultural and textile students, and to all engaged in the cotton trade.

The purposes of classifying cotton are to aid (1) in determining the comparative values of the different qualities and (2) in describing the cotton so as to make buying and selling more satisfactory when samples are not available. With the present method of buying cotton, especially the short-staple varieties (three-fourths of an inch to $1\frac{1}{16}$ inches), other things being equal, the grade has been the chief factor considered. In some cases, however, very little discrimination seems to be made even on this score.[1] What is known as staple cotton ($1\frac{1}{8}$ inches in length of staple or longer) is usually sold on type or sample. The sample gives each party to the trade a chance to form his own opinion, and is necessary because cotton dealers and spinners have different ideas about the actual length of staple.

CLASSIFICATION ACCORDING TO GRADE.

GRADE NAMES.

The Official Cotton Standards of the United States for white cotton were established and promulgated on December 15, 1914, by the Secretary of Agriculture, in conformity with the United States cotton futures Act of August 18, 1914. After the reenactment of the act on August 11, 1916, they were reestablished and include the following grades:

1. Middling Fair.
2. Strict Good Middling.
3. Good Middling.
4. Strict Middling.
5. Middling.
6. Strict Low Middling.
7. Low Middling.
8. Strict Good Ordinary.
9. Good Ordinary.

This range of grades covers practically all the white cotton grown in an average season. Figure 15, showing cotton of the grades Middling Fair and Good Ordinary, represents the extreme range of grades covered by the Official Cotton Standards of the United States.

Under the terms of the United States cotton futures Act each of the above standards is recognized as a full grade, and each grade will be so treated in this bulletin. Middling, as the name indicates, is the middle or basic grade, and is the grade upon which the market quotations are based. All grades above Middling should bring higher prices, and all below Middling lower prices than that quoted for Middling, the amount above or below varying according to the commercial differences in use where the cotton is marketed.

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[1] See Taylor, Fred, Relation between primary market prices and qualities of cotton. U. S. Department of Agriculture Bull. 457, 1916.

Other names are used to describe the different classes of colored cotton. The grades of white cotton, however, are the foundation of all these other classes. When the cotton is not white its nature or class is customarily indicated by adding to the grade the words "off color," "spotted," "yellow tinged," or "yellow" or "blue stained," as the case may be. In other words, at some markets there may be several classes of the same grade of cotton; e. g., Middling off color, Middling spotted, Middling yellow tinged, or Middling yellow or blue stained.

FACTORS THAT DETERMINE THE GRADE.

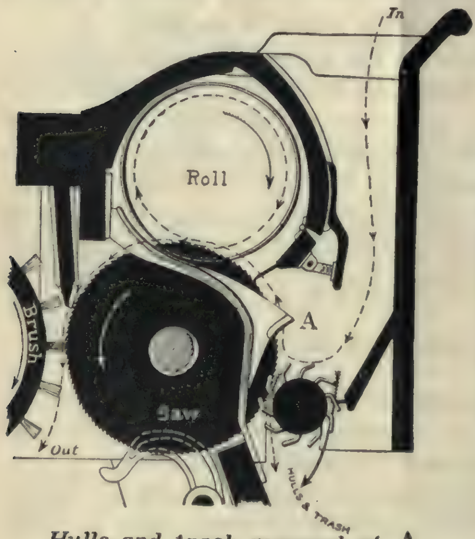
The principal points to be considered in deciding the grade of cotton are (1) foreign matter or impurities, such as leaf, dust, sand, motes, and cut seed; (2) color; and (3) quality of ginning.

With cotton that can be classed as white, the amount of foreign matter or impurities is of greater importance than color in determining the grade. The cotton merchant, in filling the spinners' orders, must rate the length, strength, body, cling or drag, and uniformity of the staple, as well as the grade. The relative spinning values, therefore, will be considered apart from the grade.

FOREIGN IMPURITIES.

Leaf, dust, and sand.—The amount of leaf, dust, and sand in cotton depends largely upon the weather. Usually there is very little leaf when cotton is picked before the vegetation is killed by frost.

Practically all low-grade cotton carries a trace of dust or sand, or often both, which to a limited extent affects the grade. When, however, there is an abnormal amount of either dust or sand, a penalty separate from that for grade is made. As much as 50 pounds more of these impurities have been extracted from one bale of low-grade cotton by the use of cleaners at the gin. If up-to-date machinery were used for the whole crop, there would be few bales below Low Middling in grade. If cotton were sold on grade, the increase in price should offset the loss in weight, and at the same time the cost of ginning would be reduced, since such cost frequently is based on the weight of lint cotton ginned. Much of the leaf, dust, sand, and hulls may be removed by the use of "huller" gins (see fig. 1). Cleaners properly used in connection with any type of gin also improve the sample from one to two grades. Either type of gin (see fig. 2), however, turns out a cleaner and better sample if the cotton is thoroughly dry when ginned and the saws, brushes, and other parts of the gin are in good condition.[1]



Hulls and trash removed at A

FIG. 1.—Sectional view of huller gin.

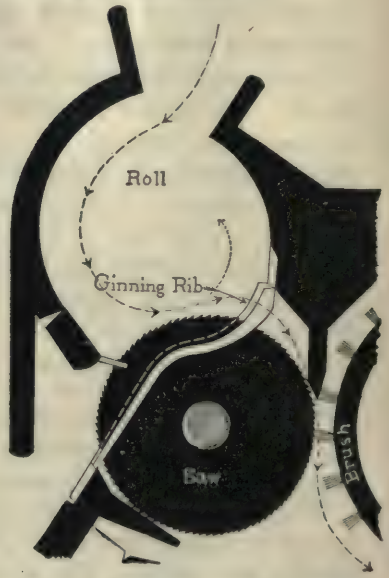


FIG. 2.—Sectional view of plain gin.

Motes.—Motes (fig. 3) are immature seeds or ends of seeds, that are pulled off in ginning. Immature seeds are found more or less in all cotton, the number depending upon the variety and the weather conditions during its growth and maturity. Their presence lowers the grade of cotton, as they go out as waste in the manufacturing processes.

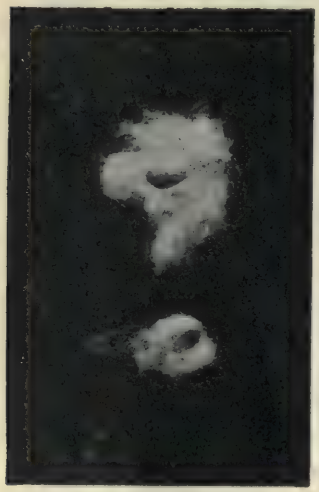


FIG. 3.—Motes.

QUALITY OF GINNING.

A properly ginned sample (fig. 4) is smooth, while a poorly ginned sample may contain neps, gin-cut staple, or may be stringy and rough in appearance.

Neps and gin-cut staple.—Neps and gin-cut staple (figs. 5 and 6) may be caused by feeding cotton to the gin too fast, by the gin being in bad order, by the presence of immature staple, or by dampness in the cotton when ginned. Neps look like small white dots. They may be seen best when a thin layer of the cotton fibers is held toward the light. The cut fibers show in bunches and V-shaped kinks, thus giving the sample a rough appearance. It is difficult to judge the grade or value of gin-cut cotton, so, in order to be on the safe side, the buyer often penalizes such cotton from one-half to two cents per pound.

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[1] See Taylor, Fred, Griffith, D. C., and Atkinson, C. E., Cotton ginning information for farmers, U. S. Department of Agriculture Farmers' Bul. 764, 1916.

Stringy cotton.—Stringy cotton (fig. 7) is defective cotton produced by the ginning of wet or immature seed cotton, or sometimes by the wrong adjustment of the brushes that take the lint away from the gin saws (see fig. 1). The fibers in these strings

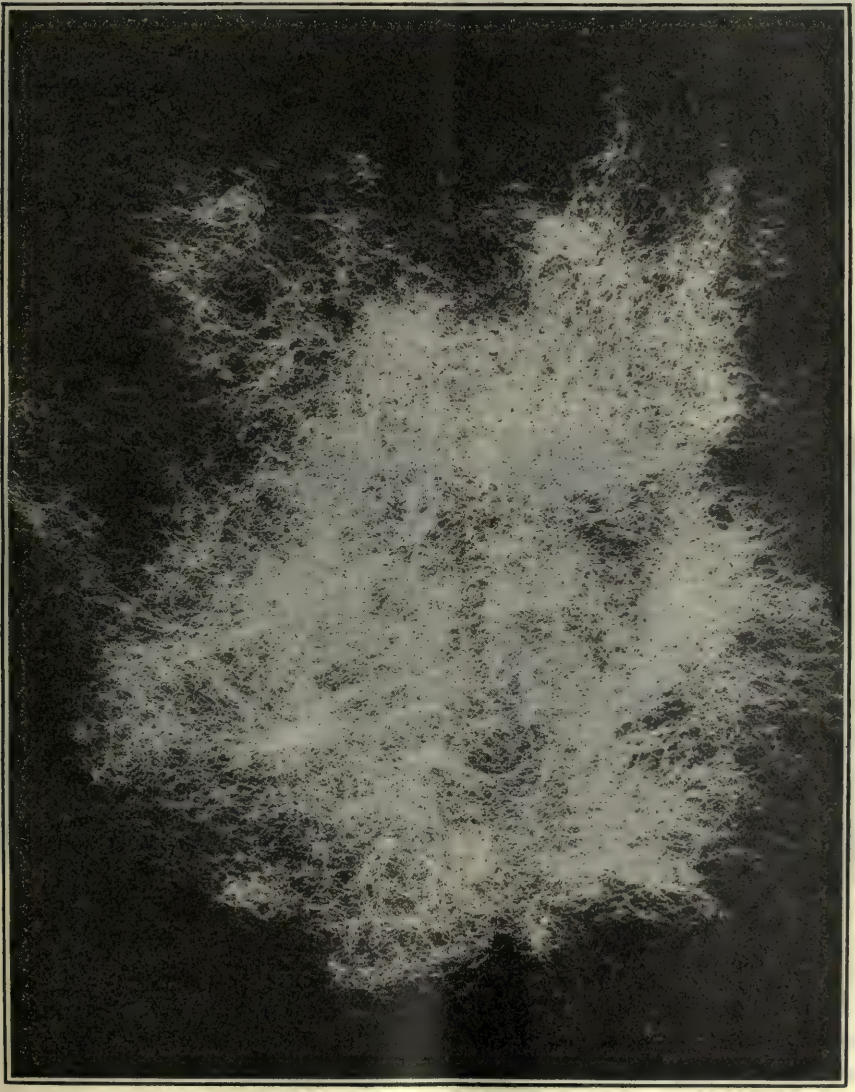

FIG. 4.—Smoothly ginned cotton.

do not separate very easily, while many of them are discarded in the first cleaning processes at the mill and go into the waste.

Cut seed.—Cut seed (fig. 8) are caused by fast ginning with a hard roll, and by broken or bent gin saw teeth that strike the grate bars. Cut seeds have their effect upon the eye and touch in grading, increase the amount of waste and reduce the grade according to the amount contained in a given sample.

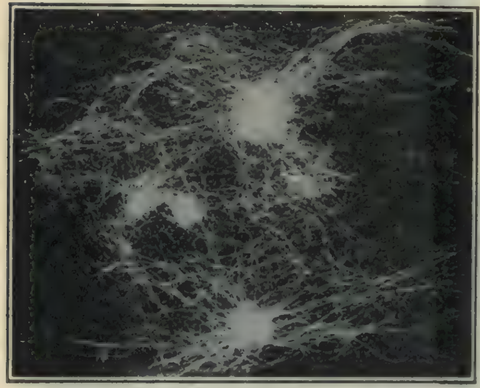

FIG. 5.—Neps.

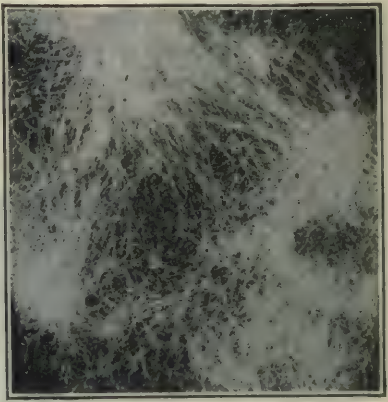

FIG. 6.—Gin-cut staple.

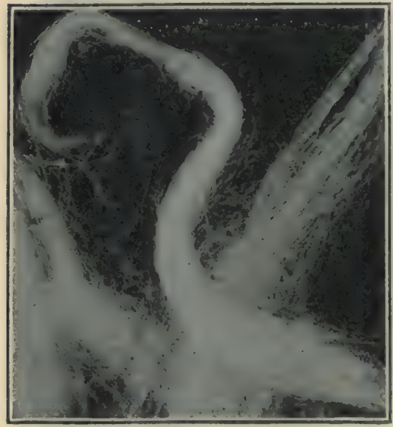

FIG. 7.—Stringy cotton.

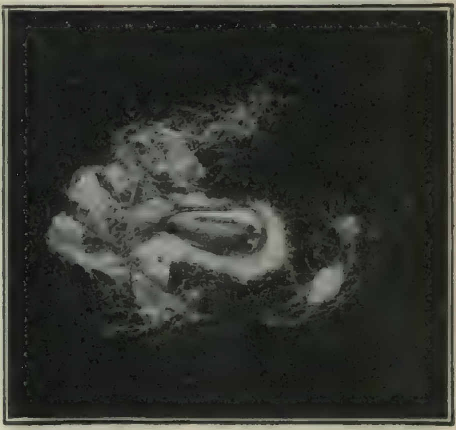

FIG. 8.—Cut seed.

COLOR AS ASSOCIATED WITH GRADE.

The Official Cotton Standards of the United States for grade require that cotton grading Strict Good Middling or above be of a bright, creamy, or white color, and free from any discoloration. A definite or fixed color is not absolutely required in the grades below Strict Good Middling. For instance, a sample grading Middling may be creamy or "dead" white, and this identical color might be found in a sample grading either Strict Middling or Strict Low Middling. In the grades below Middling, however, the bright creamy color or bloom is usually lost, since climatic and soil conditions, that lower the grade to this extent, also affect the color, often giving either a "dead" white, a gray, or a dingy or reddish cast to the lower grades, although they pass commercially as white cotton. The meaning of the word "white" is therefore relative when applied to cotton.

Variations in color can best be seen when the cotton is placed in a north light. If working out of doors, the grader's back should be turned toward the sun so that his line of vision will be more or less parallel to the rays of light. The best light for grading may be had on a clear day during the hours from 9 a. m. to 3 p. m. It is sometimes difficult to judge the color of cotton on a day that is cloudy or partly cloudy because of improper or reflected light.

CLASSIFICATION ACCORDING TO COLOR.

NAMES OF COLOR STANDARDS.

In conformity with the authority given by the United States cotton futures Act of August 18, 1914, the Secretary of Agriculture on January 28, 1916, established and promulgated standards for color which were reestablished and promulgated immediately after the reenactment of the act on August 11, 1916. These standards cover the following colors and grades:

Yellow Tinged Cotton of the grade of Low Middling.
Yellow Tinged Cotton of the grade of Strict Low Middling.
Yellow Tinged Cotton of the grade of Middling.
Yellow Tinged Cotton of the grade of Strict Middling.
Yellow Tinged Cotton of the grade of Good Middling.
Yellow Stained Cotton of the grade of Middling.
Yellow Stained Cotton of the grade of Strict Middling.
Yellow Stained Cotton of the grade of Good Middling.
Blue Stained Cotton of the grade of Middling.
Blue Stained Cotton of the grade of Strict Middling.
Blue Stained Cotton of the grade of Good Middling.

There is a greater diversity of opinion in the trade concerning the grade and value of these three classes of colored cotton than is the case with white cotton. It is estimated that on an average about one-fifth of the American cotton crop falls within the above standards for color. The economic advantage of uniform standards for handling these classes of cotton is therefore obvious. The names and methods as now applied in the classing and grading of colored cotton by the Official Cotton Standards of the United States as above named are slightly different from those formerly used by the trade.

Each of the color standards now contains approximately the same amount of leaf and foreign matter as the corresponding grade of the white standards. The yellow tinges and yellow stains formerly were referred to merely as "tinges" and "stains," respectively, and the intensity of the color decided, in many cases, the grade assigned to the sample. In so far as authentic information is at hand, there never had been a separate standard for blue cotton in general use, either in America or Europe. Heretofore such cotton has been classed largely according to its value based on the white standards for grade, or else it has been sold on type or sample.

FACTORS THAT INFLUENCE THE COLOR.

The weather and the soil are factors that influence the color of cotton. The early pickings, when not exposed to rain, usually have a bright, creamy color, and if picked with ordinary care should class perhaps good middling or better in grade. If left in the field too long, however, the luster is lost and the color of the cotton changed to a "dead" or grayish white that may reduce the grade to Middling or perhaps below, depending upon the quantity of leaf and foreign matter. The action of frost on the late bolls before they open may change the cotton to a different color class, as Middling Yellow Tinged, or Middling Yellow Stained, according to the degree of color. The yellow tinges are mixed with white cotton in variable proportions, while the yellow stains are of almost a solid yellow, reddish, or buff color. Cotton grown on red soil also may be discolored by the rain during the harvesting season.

Blue color in cotton is a stain usually due to mildew, caused by exposure in the boll to continued rains, together with staining from the dead vegetation of the plant. Such color also may be due to exposure after the cotton is ginned and baled.

CLASSIFICATION ACCORDING TO LENGTH OF STAPLE.

It is usual in the trade to call cotton that averages in length of staple 1⅛ inches or more "staple cotton" and that which averages less than 1⅛ inches "short-staple" cotton.

Long-staple cotton, with the exception of Sea Island and Egyptian, is classed according to grade in practically the same way as short-staple cotton, although graders are usually more liberal as regards curls, strings, and general smoothness of the cotton. The reason for this is that in ginning long-staple cotton with either the saw or roller gin the fibers become more tangled, forming curls and strings which affect the general smoothness of the cotton. Another reason is that the length and general character of long-staple cotton are the principal factors that decide the price. The buyer looking for a lot of cotton with the desired length of staple will not be as particular with the grade, within certain limits, as with the staple.

There is no fixed length of staple used as a basis in many of the primary markets for what is known as "short cotton." At present, very little difference is made by local buyers in the prices between different lengths of cotton ranging from three-fourths of an inch to 1 inch if the grade and other qualities are equal. One-inch cotton, however, is worth perhaps just as much more above three-fourths of an inch cotton as Good Middling is worth above Middling, and should bring a corresponding premium. It is only a question of time, it is believed, when closer distinctions will be made in this respect.[1]

Table I shows roughly the average premiums that have prevailed for the past three years (1913–1916) for the various lengths of staple of 1⅛ inches to 1½ inches for Strict Middling Delta cotton, based on the price of Strict Middling short cotton of the same growth. These premiums are only approximate averages, and, of course, vary considerably from year to year according to supply and demand.

TABLE I.—*Averages of premiums for Strict Middling Delta cotton 1⅛ inches to 1½ inches in length of staple, based on price of Strict Middling Short cotton of the same crop, 1913–1916.*

Length of staple.	Premium.
Inches.	*Cents.*
1⅛	1½
1 3/16	2¾
1¼	4
1 5/16	5¼
1⅜	6¾
1 7/16	7½
1½	9

The premiums usually are relatively higher for Delta cotton, owing to its more desirable character, than for cotton of the same grades and lengths of staple grown in other sections. In the case of staple cotton the premiums are relatively higher for the grades above Middling, and the penalties greater for the grades below Middling, than with short cotton, since staple cotton is used in the manufacture of fine goods, where clean yarn of a bright color is desired. Nevertheless, every additional one-sixteenth of an inch in the length of the staple usually adds more to the market value of staple cotton than does the difference of a grade in its classification.

Length of staple is determined by a process know as "pulling the staple." A small piece of cotton is grasped with both hands and pulled apart. One-half is then discarded, and the ends of the fibers projecting from the portion held usually in the left hand are grasped between the thumb and forefinger of the right hand and drawn from the mass. Two or three such pulls are made and the staple is then lapped back and forth until the fibers are parallel and the ends squared before the length is estimated. The character of the staple—that is, its strength, body, drag, and uniformity—is also noted at the same time.

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[1] For a discussion of the agricultural importance of such distinctions in encouraging improvement in cotton production, see Cook, O. F., "The relation of cotton buying to cotton growing," U. S. Department of Agriculture Bulletin 60, 1914.

There is a greater difference of opinion concerning length of staple than there is concerning grade. Different experts vary considerably in their estimates of the length of the same sample of cotton, sometimes from one-eighth to three-sixteenths of an inch in the longer lengths. This is often due, no doubt, to the fact that they do not "pull" the staple in the same way. A rule used for measuring the drawn sample, therefore, is not always a sure index of the length, for one classer may discard more short or long fibers than another. If, however, all branches of the trade had the same type or standard sample of cotton for 1 inch, 1⅛ inches, and 1¼ inches, etc., cotton could be compared with the standard, both being pulled in the same way, and doubtless a greater uniformity could be established. At present what the spinners at New Bedford, Mass., and other fine yarn spinners in the East call 1⅛ inches other sections of the country may call 1¼ inches.

The need of such a standard is recognized, but the maintenance of a standard of the same general character as well as length year after year for the different lengths of staple presents serious difficulties. Merchants find it necessary to spend a large sum selecting bales at the beginning of each season from which types are sent to their various customers, and make their sales not with reference to a given length of staple but in conformity with the types furnished.

CLASSIFICATION ACCORDING TO CHARACTER.

In addition to the above classifications covering grade, color, and length of staple, the value of any cotton for spinning purposes is also largely influenced by its character, which refers to the strength, body, drag, and uniformity of staple.

These characteristics vary in cotton from year to year, owing to the season, soil, fertilizer used, and variety of seed planted. It has not thus far been found advisable, therefore, to attempt to maintain uniform standards covering these variable characteristics in the staple of cotton.

Strength.—Strength of fiber is one of the principal spinning qualities of cotton, for upon this—other characteristics being equal—depends the strength of the yarn. The soil, variety, time of maturity, and season or climate are the factors that influence the strength of the staple. The second or third picking, made before the top crop opens, often gives a better character of staple, and sometimes longer staple, than is found in the first picking. Generally speaking, however, the staple in a Good Ordinary or Low Middling sample is weaker than that of the higher grades, owing to weather exposure and perhaps to immature staple that is often found in these grades from the top crop. Stained cotton and, to a lesser degree, tinged cotton usually is found to be of weaker staple than that of the corresponding white grade. These lower grades and classes of cotton often contain immature staple and at times perished staple. Immature staple usually has a glossy appearance, and the fibers are often matted together (see fig. 9). Bolls of cotton that are picked before they are well opened, and also the top bolls when forced open by the action of frost, contain immature staple. Cotton of perished staple is such as has had the strength of fiber destroyed or unduly reduced through exposure either to the weather before picking or after baling, to heating by fire, on account of water packing, or through other causes.[1] Immature staple or perished staple is undesirable for manufacturing purposes; it makes weak yarn, and a large amount of waste. The market value of such cotton is accordingly reduced.

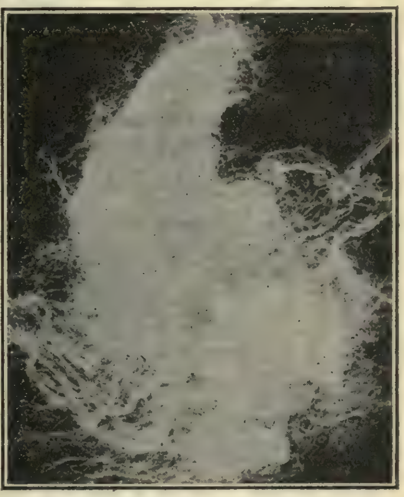

FIG. 9.—Immature staple.

Body and drag.—The body of cotton is closely related to its strength, while drag refers to the cling or resistance offered when a tuft of the sample is being pulled or broken. Heavy-bodied cottons are usually grown on bottom or fertile land, while the lighter-bodied cottons are produced on thin soil or under adverse weather conditions.

Uniformity in the length of staple is of equal importance to that of strength or body to the manufacturer, for the amount of waste in the manfacturing processes depends largely upon the degree of uniformity in the staple of the stock used. Wasty or uneven staple in cotton may be caused by planting poor varieties or mixed seed of two or more varieties, or by poor ginning. Several years of careful selection of a suitable variety is necessary in order to develop a uniform quality of fiber.

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[1] See U. S. Department of Agriculture, Office of Markets and Rural Organization, Service and Regulatory Announcements No. 10, 1916.

TRADE NAMES AND REGIONAL CHARACTERISTICS.

There are certain grade characteristics in cotton that often indicate the section of the country in which the cotton was grown. The sections most commonly referred to in the American cotton industry are three in number and give rise to cotton of three regional trade names—Upland, Gulf, and Texas. Each of these types is subdivided and sold under many other trade names that tell more nearly the character of the cotton and where it was grown. All American cotton, however, except Sea Island and Arizona-Egyptian, is of the Upland species.

Upland cotton.—The "Upland" type of cotton constitutes the bulk of the American crop and is perhaps the most generally used cotton grown. It is produced almost throughout all the inland districts of the cotton-growing States, but chiefly in North Carolina, South Carolina, Georgia, Alabama, Tennessee, and Virginia. Much cotton that is grown in the hilly parts of Mississippi, Louisiana, Texas, and Arkansas is sold as Upland. This cotton averages seven-eighths of an inch to 1 inch in length of staple, although a number of long-staple varieties up to $1\frac{5}{16}$ inches in length are being grown successfully in the Upland districts. In parts of the Piedmont section, shown on the soil map (fig. 10) by the letter D, the length is very often more than 1 inch, while in the sand hills and coastal plains a considerable amount is often less than seven-eighths of an inch, and more fluffy in appearance. Cotton grown in the Piedmont section generally has a bright, creamy color, or "bloom," which is considered desirable by many spinners. The leaf is usually black and in rather small pieces, while in the cotton from the sandy soil the color is generally whiter and the leaf larger and brighter. Atlantic States cotton changes color faster when left in the field than western cotton. It takes on a bluish cast and is often spotted or tinged if grown on a red clay soil. This is no doubt due, in part at least, to the greater rainfall in the Eastern States during the gathering season (see fig. 11.)

Gulf cotton.—As the name indicates, "Gulf" cotton is grown in the States bordering on the Gulf of Mexico and in the basin of the Mississippi River. In using this name, many in the trade seem to refer to a cotton of $1\frac{1}{16}$ inches staple or something better than the ordinary seven-eighths of an inch to 1 inch Upland cotton, regardless of whether it is grown on the Gulf or not. The length of staple, however, does not decide the grade or the regional trade name, for a considerable quantity of $1\frac{1}{16}$ inches to $1\frac{1}{8}$ inches cotton is grown in the Upland districts. The general color of Gulf cotton is whiter and the particles of leaf often larger and blacker than that in either Upland or Texas cotton. It also has what is known in the trade as a "heavier body."

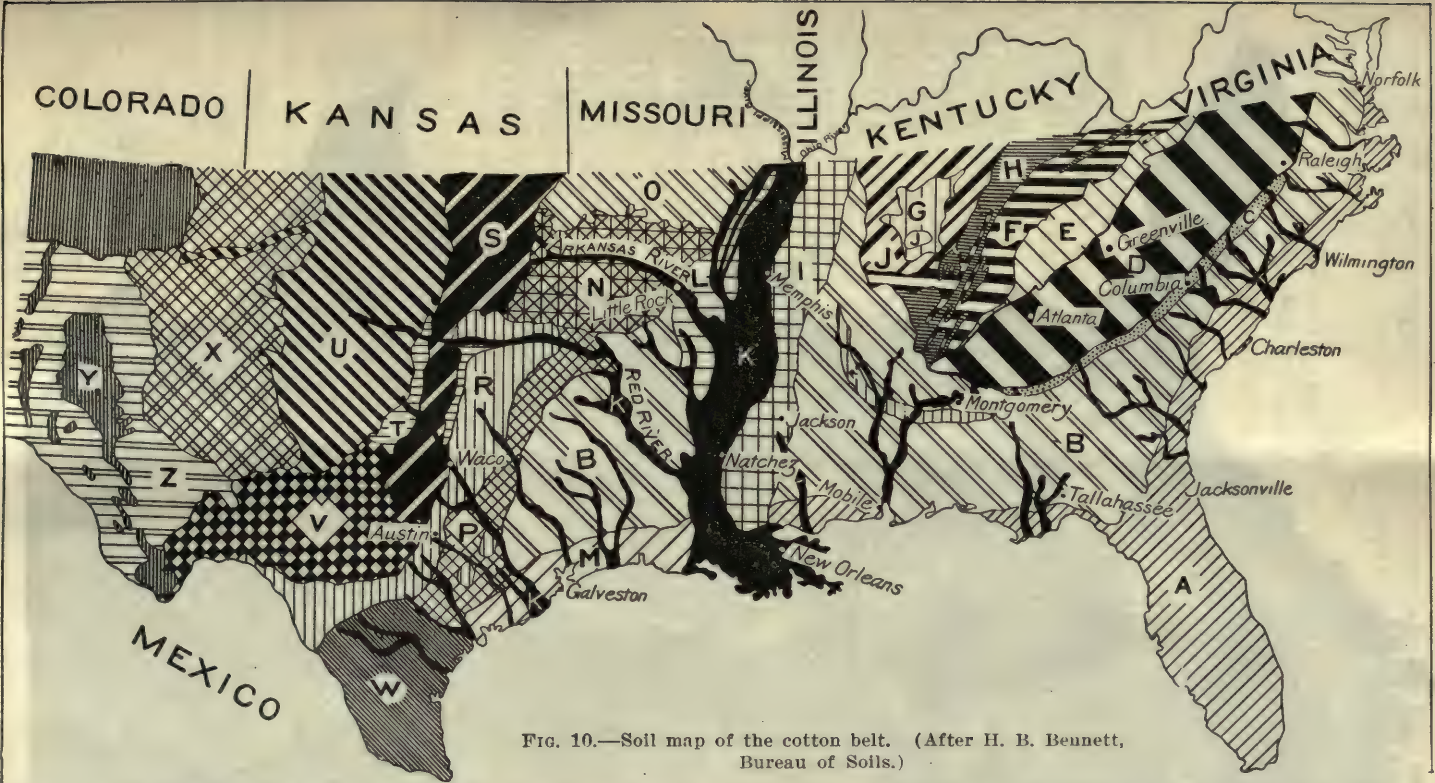

FIG. 10.—Soil map of the cotton belt. (After H. B. Beunett, Bureau of Soils.)

EXPLANATION.—*A,* Atlantic and Gulf flatwoods. Light-colored sands and dark, poorly drained soils predominate. *B,* Interior Atlantic and Gulf coastal plains. *C,* Sand hills. *D,* Piedmont plateau. *I,* Loessial region, silt and loam. *K,* River flood plains, subject to overflow. *L,* Silty terrace lands. *M,* Coastal prairie, low flatland, marshy near coast. *N,* Ozark and Ouachita Mountains. *P,* Coastal plain, mixed "post-oak land" and prairie. *R,* Black prairie, calcareous black-waxy lands. *S,* Black prairie, sandstone, shale, and limestone. *U,* Red prairie, sandstone, and shale soils. "Red Beds" region. *V,* Edwards and Stockton plateaus. *W,* Rio Grande plain. *X,* Staked plain.

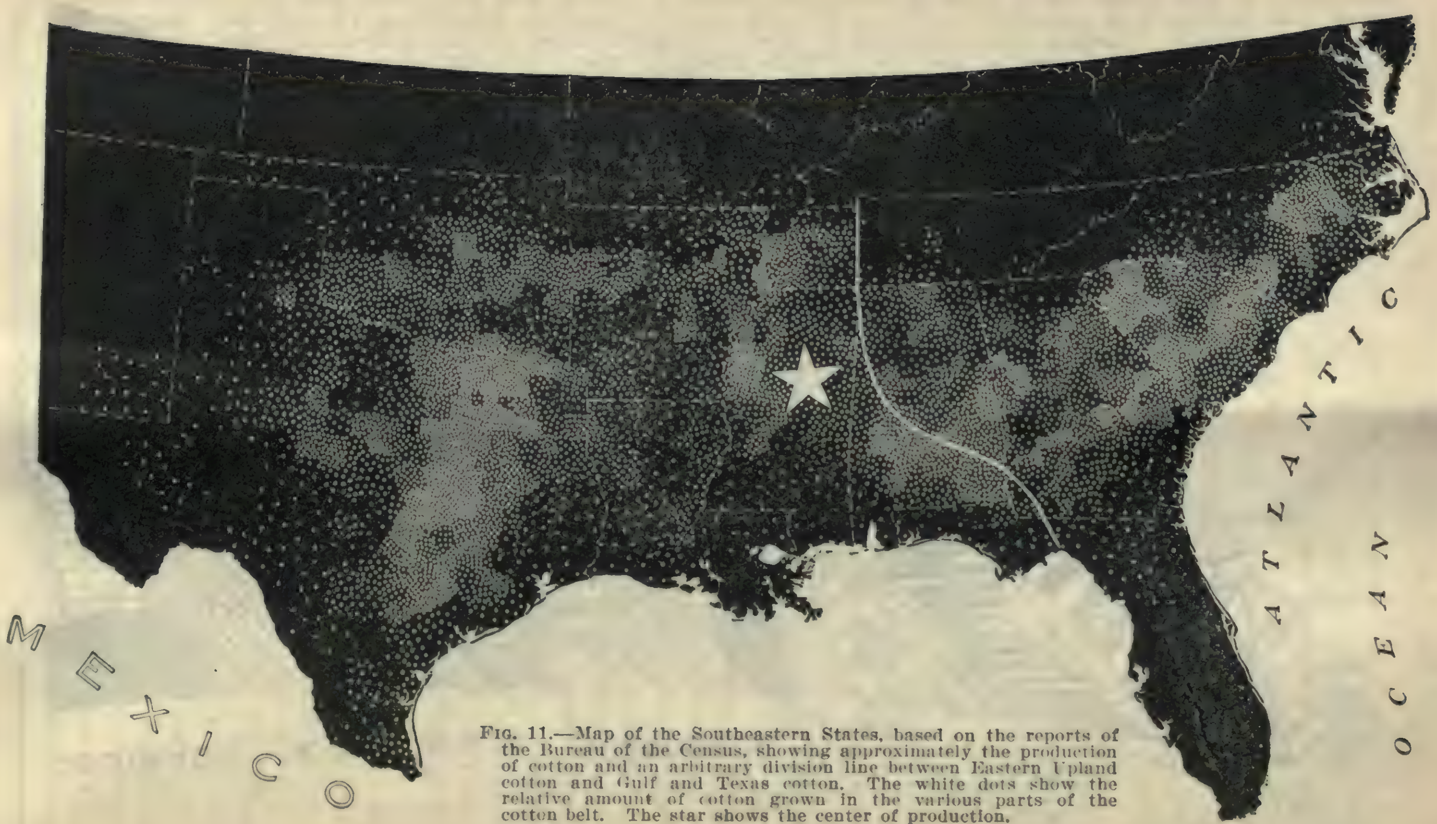

FIG. 11.—Map of the Southeastern States, based on the reports of the Bureau of the Census, showing approximately the production of cotton and an arbitrary division line between Eastern Upland cotton and Gulf and Texas cotton. The white dots show the relative amount of cotton grown in the various parts of the cotton belt. The star shows the center of production.

The word "Gulf" is not used much in the actual buying and selling of cotton, other trade names that have a more definite meaning being employed. The most common of these trade names are "Peelers," "Benders," "Rivers," "Canebrake," and "Red River," although a number of so-called varieties may be sold under each of these names.

"Peelers" was formerly a varietal name which is now seldom used, but when used is applied rather indiscriminately to the $1\frac{1}{4}$-inch Mississippi delta cotton.

"Benders" is not a varietal name. It is applied to cotton of good body, $1\frac{1}{8}$ to $1\frac{3}{16}$ inches in length of staple, which is grown along the Mississippi, Arkansas, and White Rivers. The word is said to have applied originally only to cotton that grew in Mississippi, Louisiana, and Arkansas and along the bends of the Mississippi River.

"Rivers" is used in referring to bottom-land cotton having a medium-bodied staple of $1\frac{1}{16}$ to $1\frac{1}{8}$ inches, though if the cotton has a light body it is sometimes called "Creeks" in some sections of the Mississippi Delta.

"Canebrake" is the name applied to cotton that is grown in the south-central part of Alabama on the strip of black prairie land shown on the soil map (fig. 10) by the letter "r." Most of this cotton has a strong $1\frac{1}{16}$ inch staple and brings a higher price than other Alabama cotton.

Texas cotton.—"Texas" is the trade name given to cotton grown in Texas and Oklahoma. This generally has about the same length of staple as Upland cotton except that grown in the river basins and black prairie, where the length is usually $1\frac{1}{16}$ to $1\frac{1}{8}$ inches. Texas cotton is considered to be of better spinning value than ordinary Upland cotton on account of its "heavy body" even though the staple is the same length. The character of the fiber of Texas cotton varies considerably from year to year. When the growing season is dry, the fiber is harsher and shorter than usual, while the color may have a reddish tinge. Many of the leaves are dried up early in the picking season by the heat and drought. This, no doubt, accounts for the fact that the leaf in this cotton is a brighter color and more broken or peppery than it is in either the Gulf or Atlantic States cotton. A large quantity of boll hulls, shale,[1] and stalk is often found in this cotton, especially in Oklahoma and northern Texas, where all of the top crop does not mature, owing to the shorter growing season.

These half-opened bolls and the bolls that do not open at all are usually ginned in a "double-rib" huller gin, and the cotton is known in the trade as "bollies." "Bollies" are usually of a bright yellowish color and the staple is softer and more fluffy than that in normally matured cotton.

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[1] The inner lining of the boll, resulting from the crushing and separation of the boll hulls from the cotton at the gin, is known as shale.

Another type of cotton, known as "snapped," or "machined" cotton, where the open and mature bolls have been gathered with the bur, is found in this section near the end of the picking season. This cotton, although often resembling "bollies" in the amount of shale and hull contained in it, has a superior fiber and may be graded in the usual way.

CLASSIFYING BY STANDARDS.

In order to obtain uniformity in the classification of cotton, an occasional reference to the standards is desirable. The light causes the same cotton to appear very different at times. Classers often disagree as to the grade or class of a sample, even after reference has been made to the standards. For beginners it is easier to match cotton against the standards if types of the cotton to be graded are placed for the time being in a box similar to the boxes containing the types of the standards. (See Fig. 12.) The cotton in question may then be matched by placing the prepared box of cotton to be classed by the side of the boxes containing the stand-

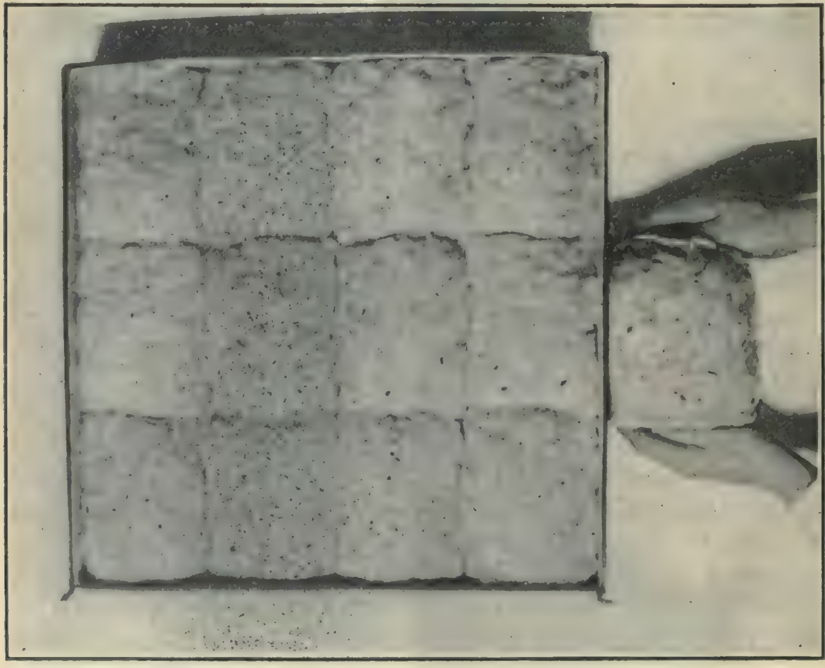

FIG. 12.—Grading by standards.

ards until the class is determined. This method gives a greater surface for comparison and also practically the same light on each box.

The Official Cotton Standards of the United States were prepared with a view of representing the various characteristics of cotton grown throughout the cotton belt. In making copies of these standards for sale, cotton has been selected from almost every cotton-growing state. Each grade box contains twelve samples, so as to indicate the slight range or diversity allowed within the grade; for example, there may be one type of Low Middling of a reddish cast with bright leaf, and another of a grayish or bluish cast with black leaf; in one sample the leaf may be in large pieces, while in another it may be broken up in small pieces known as "pin" leaf. The same variation is found within the grade boxes of each of the nine official grades, the diversity being less marked above Middling than below. Still more latitude has been allowed in the preparation of the standards for color. For instance, in the same box, a Middling Yellow Tinged type from Oklahoma may have a reddish cast, while a Middling Yellow Tinged type from Georgia or Alabama may have a dull or grayish cast.

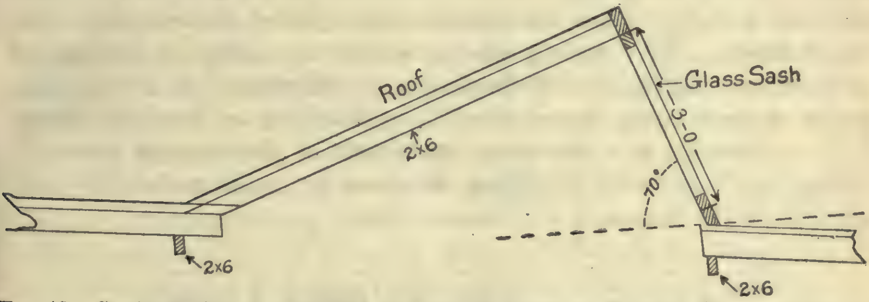

FIG. 13.—Sectional view of a skylight that may be placed on the roof of a warehouse or cotton shed, in order to get a north light for grading.

The cotton classer is continually encountering bales that will pass for a certain grade or class of cotton although they do not resemble identically any particular type in the standard. In reality, no two bales of cotton are exactly alike. Many samples must be assigned to a certain grade according to their valuation based on the standard.

A skylight is considered more desirable for viewing cotton than a sidelight. However, when it is not feasible to add a skylight (see fig. 13), several large windows may be placed side by side preferably in the wall facing north.

The table for holding the grade boxes should have a top inclined toward the light at an angle of approximately 30° in a room where a skylight is used, and at about 45° where the side light is used.

SAMPLES FOR USE IN CLASSIFICATION.

In sampling a bale of cotton for classing, about three ounces should be drawn from each side of the bale. When samples are drawn from a bale of compressed cotton they should be exposed to the air before grading, so that the matted condition and deadened color may disappear. Classers are liberal in grading compressed cotton, because the leaf and dirt are more condensed, and the general appearance of the sample is rougher. An allowance of about one-half grade should be made when classing compressed cotton, especially of the lower grades, immediately after sampling.

Recent experiments have been made by the Office of Markets and Rural Organization in order to determine the effect of compression upon the grade of cotton. These tests were conducted on three 100-bale lots which were obtained in New Orleans, La., Gadsden, Ala., and Little Rock, Ark. A sample was taken from each bale of cotton before compression; these samples were then graded very carefully and the average grade determined.

Each of the three 100-bale lots was then sent to a compress and compressed in the usual manner. Samples were again drawn from each lot five days after compression and graded immediately after being drawn. They were graded a second time after an interval of 24 hours and again a third time after an interval of 48 hours. The grade of these bales ranged from Low Middling to Good Middling.

The following is a condensed statement of the average prices in points "on" or "off" Middling obtained by grading the 300 bales handled in the manner as above outlined:

Total number of bales.	Grading before compression.	Grading immediately after compression.	Grading 24 hours after compression.	Grading 48 hours after compression.
300	3 points on Middling.	11 points off Middling.	2 points off Middling.	3 points on Middling.

It will be noted that the average price on the third grading, which was made 48 hours after the samples were taken from the compressed bales, is identical with the average price of the cotton previous to compression.

Samples from bales should be drawn in smooth sheets, and preferably when the bale is dry. The sample being classed should be unfolded three or four times and examined, since the leaf and dirt are not always evenly distributed. This unevenness is largely due to the fact that the cotton in any such sample came from several parts of the field and was perhaps picked by a number of persons. The different pickings made from time to time are often stored together, and this may give a considerable variation, especially during the latter part of the season. It is also the custom in some sections for cotton to be sold in the seed at the gin.[1] Many loads of cotton originating in different sections are thus mixed in one large bin before ginning. This practice also causes mixed grades and qualities of cotton.

Many bales have on one side a thin "plate" that is of a higher or lower grade than the rest of the bale. Plating is usually caused by a "roll" being left in the "breast" of the gin from cotton of a different lot previously ginned. A sample from such a bale should be drawn, therefore, from a sufficient depth to be fairly representative of the bale. Plated bales have no doubt caused great loss to the producers, as cotton is classed on the basis of the low side or poorest quality shown in the bale.

CARE OF THE PRACTICAL FORMS OF THE STANDARDS.

Very few people seem to realize the importance of protecting the copies of the standards from light and dust. Only the surface of the cotton shows the grade, and exposure to light and dust will in a short time so change the appearance of the surface that it does not actually represent the grade or class as certified. It has been found necessary in the standardization work at Washington to compare the "working" sets, which are used daily as copies in the preparation of practical forms of the official standards, with the official sets each week. The luster or bloom in the high grades is bleached out by light, and this bleaching, together with the dust that collects on the cotton, has the effect of lowering the grade, while the bleaching of the color in the lower grades tends to improve their appearance.

The appearance of the standards is also found to undergo slight changes even when not in use. The surface of the samples is free from pressure, thus allowing the cotton to "fluff up," and giving it a brighter appearance, and the roughness, especially in the lower grades, also disappears to some extent. The opening of the lid has a tendency to loosen the surface and unless it is closed with care the loose leaf may be blown off or disturbed. It is considered that the types in the standards more accurately represent cotton in its natural state when free from pressure by the lid, and the official standards for grade have been so prepared. Owing to the more variable and fugitive character of the color in the colored standards, the types have been prepared so as to fill the box, allowing a slight pressure from the lid. More air is thereby excluded, and the surfaces of the types better preserved. Experience shows that when practical forms of the standards are in use they are frequently not true copies of the official standards longer than about one season, and often not that long. Color may even be destroyed within a few days if the practical forms are left exposed to light.

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[1] See Creswell, C. F., Disadvantages of selling cotton in the seed. U. S. Department of Agriculture Bulletin 375, 1916.

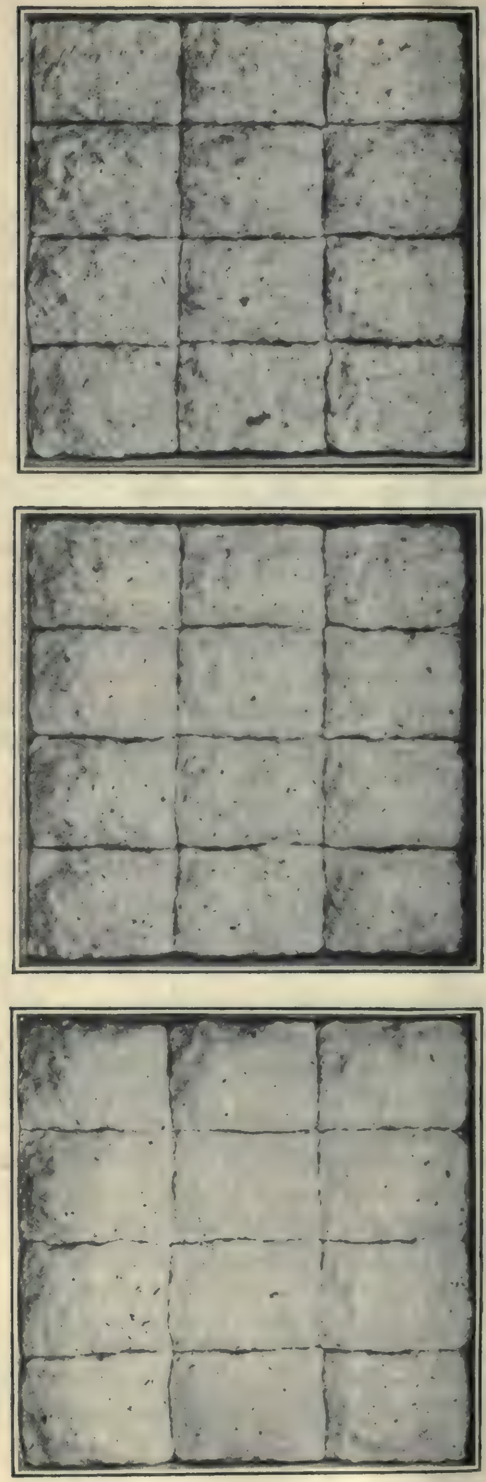

FIG. 14.—Good Middling, Middling, and Low Middling of the Official Cotton Standards of the United States. These grades cover the bulk of the white cotton grown in an average season. The use of such grades in connection with quotations from responsible markets (see Table II) should prove to be profitable for those who have cotton for sale.

RELATIVE VALUES OF DIFFERENT CLASSES.

Table II shows the average premiums and penalties in cents per pound on and off middling in various markets throughout the United States, based on the official cotton standards of the United States for grade (see figs. 14 and 15), from August 1, 1915, to August 1, 1916; while Tables III and IV give the same information based on the official cotton standards for color from March 15, 1916, when quotations were begun officially on these standards, to August 1, 1916.

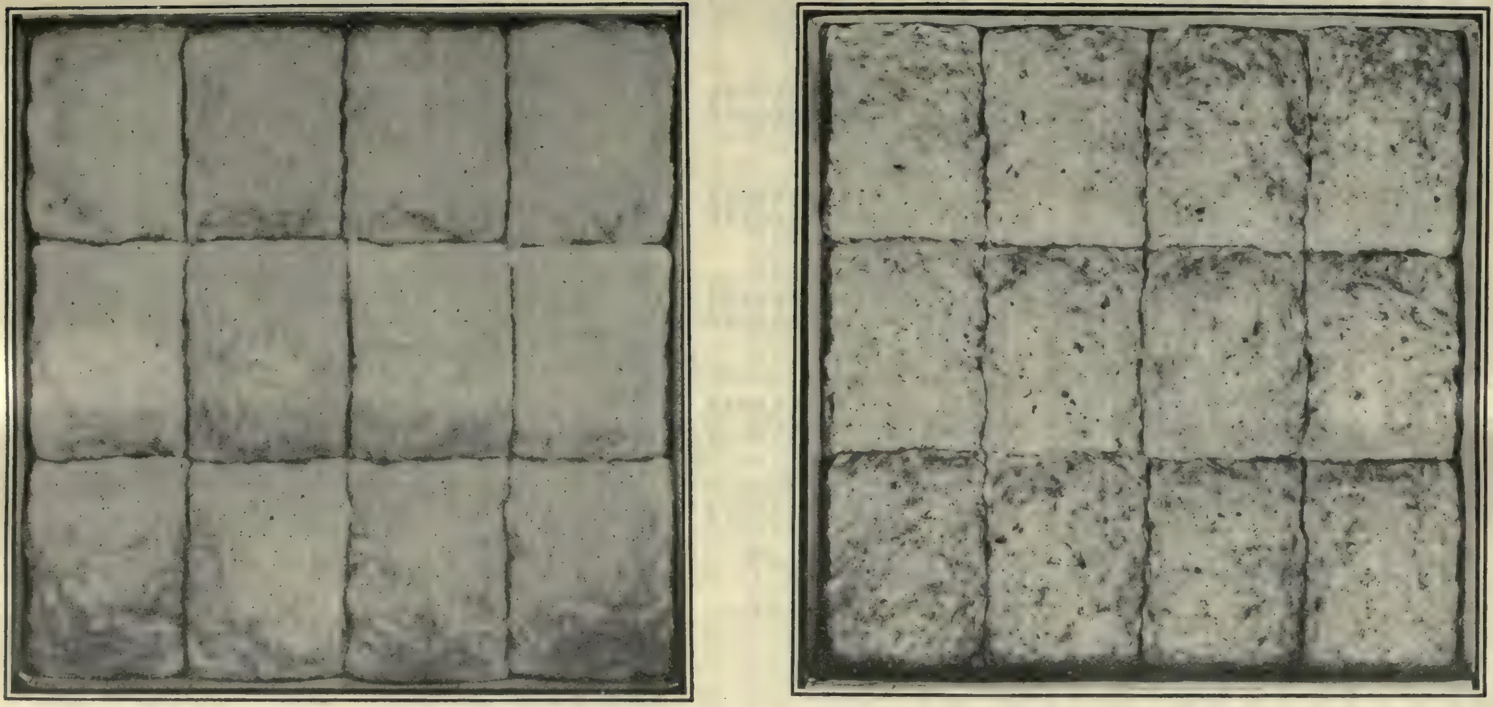

FIG. 15.—Middling Fair, the highest, and Good Ordinary, the lowest, of the Official Cotton Standards of the United States. The average quotations for Aug. 1, 1915, to Aug. 1, 1916, from 11 of the largest spot markets in the United States (Table II), showed a difference of $14.50 per bale between the value of these grades. When the average grade of the crop is lower than that of the past season the difference between the market prices of these grades is considerably wider.

TABLE II.—*Average differences in value on and off Middling for short cotton, based on the official cotton standards of the United States for grade, from Aug. 1, 1915, to Aug. 1, 1916.*

	Middling fair.	Strict good middling.	Good middling.	Strict middling.	Middling.	Strict low middling.	Low middling.	Strict good ordinary.	Good ordinary.
Norfolk	0.91 on	0.68 on	0.43 on	0.22 on	11.61	0.33 off	0.91 off	1.36 off	1.86 off
Augusta	.76 on	.63 on	.50 on	.25 on	11.53	.29 off	.72 off	1.23 off	1.79 off
Savannah	1.00 on	.75 on	.50 on	.25 on	11.72	.34 off	.80 off	1.29 off	1.77 off
Montgomery	.89 on	.75 on	.47 on	.25 on	11.37	.42 off	.90 off	1.36 off	1.74 off
New Orleans	1.33 on	.84 on	.55 on	.25 on	11.65	.29 off	.63 off	1.19 off	1.72 off
Memphis	1.23 on	.69 on	.44 on	.23 on	11.83	.31 off	.74 off	1.30 off	1.74 off
Little Rock	.72 on	.61 on	.42 on	.20 on	11.83	.35 off	.82 off	1.33 off	1.84 off
Dallas	1.00 on	.71 on	.49 on	.24 on	11.51	.42 off	.92 off	1.59 off	2.23 off
Houston	.95 on	.71 on	.47 on	.24 on	12.00	.47 off	.97 off	1.46 off	2.03 off
Galveston	1.08 on	.77 on	.47 on	.24 on	12.06	.39 off	.95 off	1.58 off	2.10 off
Boston	1.10 on	.75 on	.49 on	.25 on	....	.38 off	.85 off	1.47 off	2.20 off
Yearly average	1.00 on	.72 on	.48 on	.24 on	11.71	.36 off	.84 off	1.38 off	1.91 off

TABLE III.—*Average differences in value on and off middling for short cotton, based on the official cotton standards, for yellow tinges, from Mar. 15, 1916, to Aug. 1, 1916.*[a]

	Strict good middling yellow tinged.[a]	Good middling yellow tinged.	Strict middling yellow tinged.	Middling yellow tinged.	Strict low middling yellow tinged.	Low middling yellow tinged.
Norfolk	....	0.13 on	0.38 off	0.63 off	1.00 off	1.50 off
Augusta	0.25 on	....	Even.	.25 off	.88 off	1.25 off
Savannah	.45 on	.20 on	.05 off	.30 off	.60 off	1.00 off
Montgomery	.25 on	.25 off	.50 off	.75 off	1.13 off	1.38 off
New Orleans	.13 on	.12 off	.38 off	.63 off	.88 off	1.13 off
Memphis	....	.05 on	.20 off	.32 off	.45 off	.82 off
Little Rock	.20 on	.01 off	.25 off	.50 off	.88 off	1.38 off
Dallas	....	.10 on	.13 off	.38 off	.87 off	1.43 off
Houston	.25 on	Even.	.25 off	.50 off	1.52 off	1.32 off
Galveston	.25 on	Even.	.25 off	.40 off	1.75 off	1.25 off
Boston	.25 on	Even.	.24 off	.48 off	.88 off	1.25 off
Average	.25 on	.01 on	.24 off	.47 off	.99 off	1.25 off

[a] No official standard has been promulgated for strict good middling yellow tinged.

TABLE IV.—*Average differences in value on and off middling for short cotton. based on the Official Cotton Standards, for yellow and blue stains, from Mar. 15, 1915, to Aug. 1, 1916.*

	Good middling yellow stained.	Strict middling yellow stained.	Middling yellow stained.	Good middling blue stained.	Strict middling blue stained.	Middling blue stained.
Norfolk	0.75 off	1.00 off	1.26 off	0.75 off	1.00 off	1.50 off
Augusta	.63 off	.63 off	1.03 off	.63 off	1.00 off	1.50 off
Savannah	.10 off	.38 off	.62 off	.38 off	.88 off	1.38 off
Montgomery	.88 off	1.13 off	1.38 off	.75 off	1.00 off	1.25 off
New Orleans	.48 off	.74 off	.99 off	.40 off	.67 off	.89 off
Memphis	.12 off	.33 off	.47 off	.36 off	.61 off	.48 off
Little Rock	.63 off	.88 off	1.14 off	.83 off	1.20 off	1.45 off
Dallas	.75 off	1.00 off	1.25 off	.65 off	.90 off	1.15 off
Houston	.50 off	.75 off	1.00 off	.25 off	.50 off	.75 off
Galveston	.50 off	.75 off	1.00 off	.35 off	.62 off	.95 off
Boston	....	.70 off	....	.65 off	1.01 off	1.72 off
Average	.53 off	.75 off	1.01 off	.55 off	.85 off	1.18 off

All of the cities named are designated spot markets under the rules and regulations of the Secretary of Agriculture under the United States cotton futures Act, which furnish daily quotations.

The average of such quotations governs the differences in value of cotton of various grades on the future exchanges. These quotations show much more uniformity than existed before the general adoption of the Official Cotton Standards of the United States. The relative values of the grades of cotton—other characteristics being equal—depend chiefly upon the quantity of foreign matter, etc., that goes to waste in the manufacturing process. The difference in price of the various classes of cotton, however, will vary also in accordance with supply and demand. During a season when the grades above Middling are scarce the premiums on the price of Middling are raised, while the penalties on the grades below Middling are also greater when these grades are plentiful and vice versa. In other words, with a high-grade crop the differences are usually narrower and with a low-grade crop the differences widen.

The differences in prices may be due to a number of causes: First, the difference in the character of the cotton that is marketed at the various points; second, the facilities of the market as a shipping point to the Eastern or European points; third, the supply and demand for the different grades. There is usually a greater difference between the prices paid for the lower grades and for colored cotton, due to the difference of opinion in the trade as to the relative values of such cotton, than is the case for Middling and above.

COMPARISON OF THE OFFICIAL COTTON STANDARDS OF THE UNITED STATES FOR GRADE WITH LIVERPOOL STANDARDS.[1]

Since September 1, 1914, Liverpool has been using the so-called International Standards for Upland cotton, which were agreed to at a conference of the representatives of the American and European Exchanges in June, 1913. The Liverpool Cotton Association continued the use of its existing Standards for Gulf and Texas cotton. The International Standards have been replaced by the Liverpool Cotton Association, new standards having been adopted on March 3, 1915, effective September 1, 1916. A complete set of the Liverpool Standards, covering Upland, Texas, and Gulf cotton, have been received recently by the department, and a detailed comparison of these Standards with the United States Official Cotton Standards has been made.[2]

Liverpool uses the same names for the various grades of American cotton as those of the Official Cotton Standards of the United States, except that the prefix "fully" is used in Liverpool instead of "strict."

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[1] For a brief history of the movement to secure universal standards, see U. S. Department of Agriculture, Office of Markets and Rural Organization, Service and Regulatory Announcements, No. 7, 1916.

[2] See U. S. Department of Agriculture, Office of Markets and Rural Organization, Service and Regulatory Announcements No. 16, 1916.

Generally speaking, the Liverpool Standards for Middling and above are somewhat lower in grade than the corresponding grades of the Official Cotton Standards of the United States, while below Middling the Liverpool Standards are slightly higher in grade. The Liverpool Standards as a whole are brighter in color and contain more leaf than do the corresponding grades of the Official Cotton Standards. The Liverpool Standards also carry less color in the grades below Middling than is the case with the Official Cotton Standards of the United States.

In the following table, the names of the new Liverpool Standards (effective September 1, 1916) for American Upland cotton, are placed opposite the names of the Official Cotton Standards of the United States, to which they most nearly conform in appearance.

LIVERPOOL STANDARD.	OFFICIAL COTTON STANDARD OF THE U. S.
Middling Fair is slightly above	Strict Good Middling.
Fully Good Middling is equal to	Good Middling.
Good Middling is equal to	Strict Middling.
Fully Middling is equal to	Middling.
Middling is slightly above	Strict Low Middling.
Fully Low Middling is equal to	Strict Low Middling.
Low Middling is equal to	Low Middling.
Fully Good Ordinary is equal to	Strict Good Ordinary.
Good Ordinary is slightly above	Good Ordinary.

CLASSES AND CONDITIONS OF COTTON UNTENDERABLE ON FUTURE CONTRACT.

Section 5 of the United States cotton futures Act of August 11, 1916, in stating the form of the future contract exempt under that section from the tax imposed by the act on future contracts for cotton, provides as follows (the fifth subdivision):

> That cotton that, because of the presence of extraneous matter of any character or irregularities or defects, is reduced in value below that of Good Ordinary, or cotton that is below the grade of Good Ordinary, or, if tinged, cotton that is below the grade of Low Middling, or, if stained, cotton that is below the grade of Middling, * * * or cotton that is less than seven-eighths of an inch in length of staple, or cotton of perished staple or of immature staple, or cotton that is "gin cut" or reginned, or cotton that is "repacked" or "false packed" or "mixed packed" or "water packed," shall not be delivered on, under, or in settlement of such contract.

It has not been found practicable to attempt to represent by standards in a practical form certain kinds and conditions of cotton that are thus prohibited from being delivered on future contracts. For the purpose of determining disputes referred to the Secretary of Agriculture under the United States cotton futures Act, definitions of some of the terms have been published in United States Department of Agriculture, Office of Markets and Rural Organization, Service and Regulatory Announcements No. 10. These definitions, which are as nearly as possible in accord with the generally accepted commercial meaning of the terms, are as follows:

Gin-cut cotton.—Gin-cut cotton is cotton that shows damage in ginning, through cutting of the saws, to an extent that reduces its value more than two grades, said grades being of the official cotton standards of the United States.

Gin cutting of a less extent than that mentioned above which reduces the cotton below the value of Good Ordinary would render the cotton untenderable though the extent of injury were less than that described, as the fifth subdivision of section 5 states substantially that cotton the value of which is reduced below that of Good Ordinary shall not be delivered on, under, or in settlement of a contract.

Reginned cotton.—Reginned cotton is such as has passed through the ginning process more than once; also such cotton as after having been ginned is subjected to a cleaning process and then baled.

Repacked cotton.—Repacked cotton will be deemed to mean factors', brokers', and all other samples; also "loose" or miscellaneous lots collected together and rebaled.

False-packed cotton.—Cotton bales will be deemed false packed whenever containing substances entirely foreign to cotton, or containing damaged cotton in the interior, with or without any indication of such damage upon the exterior; also when plated (that is, composed of good cotton upon the exterior and decidedly inferior cotton in the interior) in a manner not to be detected by customary examination; also when containing pickings or linters worked into them.

Mixed-packed cotton.—Mixed-packed cotton shall be deemed to mean such bales as show a difference of more than two grades between samples drawn from the heads, top and bottom sides of the bale, or when such samples show a difference in color exceeding two grades in value, said grades being of the official cotton standards of the United States.

Water-packed cotton.—Water-packed cotton shall be deemed to mean such bales as have been penetrated by water during the baling process, causing damage to the fiber, or bales that through exposure to the weather or by other means, while apparently dry on the exterior, have been damaged by water in the interior.

Cotton of perished staple.—Cotton of perished staple is such as has had the strength of fiber as ordinarily found in cotton destroyed or unduly reduced through exposure, either to the weather before picking or after baling, or to heating by fire, or on account of water packing, or through other causes.

Cotton of immature staple.—Cotton of immature staple is such as has been picked and baled before the fiber has reached a normal state of maturity, resulting in a weakened staple of inferior value.

Cotton of seven-eighths of an inch staple.—After investigation it is likely that a standard for cotton seven-eighths of an inch in length of staple will be issued. In the meantime the examiners authorized to hear disputes will pull the cotton so that the ends will be squared off fairly well without unduly reducing the bulk of the drawn sample. When the measure is applied a fair quantity of the cotton must remain in order to show that the sample has not been pulled too fine before measuring. When thus pulled and measured as cotton experts are accustomed to do its fair average length shall be not less than seven-eighths of an inch, in order that the cotton be tenderable under a contract made in compliance with section 5 of the United States cotton futures Act.

SUMMARY.

The grade of a sample of cotton is determined by the quantity of leaf, dust, sand, motes, and cut seed it contains, together with its color and preparation or quality of ginning.

Cotton should be dry when ginned, and the saws, brushes, and other parts of the gin should be in good condition if a smooth sample is to be obtained.

Cleaners used in connection with the ginning will improve the cotton from one to two grades.

Pickings of a higher grade should be neither mixed nor ginned with pickings that are of a lower grade, since the price paid for a bale of cotton is based on the lowest grade it contains rather than on the highest grade.

Cotton should not be exposed to the weather: moisture causes it to mildew and so lowers the grade.

The new Liverpool Standards adopted on March 3, 1915, for Upland cotton, went into effect September 1, 1916.

The Liverpool Standards for Middling and above are somewhat lower in grade than the corresponding grades of the Official Cotton Standards of the United States, while below Middling the Liverpool Standards are slightly higher in grade.

The practical forms of the Official Cotton Standards of the United States should be carefully protected. The lids on the boxes containing them should be open only when a comparison is being made. Light and dust will render them unfit for use within a comparatively short time.

Low Middling, Middling, and Good Middling cover the bulk of white cotton grown in an average season, and a knowledge of these three grades is usually sufficient for the grower's use.

During the season of 1915–16 in the markets using the Official Cotton Standards of the United States, Low Middling cotton of ⅞ of an inch to 1 inch staple sold for approximately ⅞ of a cent below Middling, and Good Middling sold for ½ of a cent above Middling.

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HORSE-BREEDING SUGGESTIONS FOR FARMERS

H. H. REESE
Animal Husbandry Division

FARMERS' BULLETIN 803
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

Washington, D. C. MAY, 1917

TWO LINES of profit are derived by the use of specially selected mares on farms, viz., in raising colts, and in doing farm work.

To secure the maximum gains from this system, all the animals used for work on the farm should be brood mares.

Mares chosen for work and breeding must be well-bred, sound individuals of desirable conformation. It does not pay to raise scrub colts.

Mares doing this double duty should receive extra care and management.

The selection of a stallion is highly important. A low service fee should not tempt if the stallion is inferior.

It is advantageous to produce a uniform lot of foals. Select breeding animals with this in view.

There may be less interference with the farm work if the most mares foal in the fall.

Careful choice of matings creates greater possibilities for the offspring, but these possibilities are realized only when nourishing feed and regular attention are given the young animals.

The plan suggested is an advance toward producing better horses.

Count on the colt crop, but remember that good breeding, proper feed, and careful management are essential.

HORSE-BREEDING SUGGESTIONS FOR FARMERS.

CONTENTS.

	Page.		Page.
Profit in breeding farm mares	3	Approaching parturition	14
Selecting breeding and working mares	4	Parturition	15
Uniformity of the mares	4	Care of the foal	15
Soundness	6	Feeding after foaling	16
Selecting a stallion	8	Raising the orphan foal	17
Mating considerations	9	Weaning	18
Feeding and management of mares in foal	11	Feeding and management of young horses	19
Abortions	14	Summary	21

PROFIT IN BREEDING FARM MARES.

FINANCIAL profit results from breeding mares that earn their feed by furnishing farm horsepower. Instances of this are often cited in farm papers. It is not uncommon to read of some remarkable mare that, besides doing her share of the farm work, has raised many hundreds of dollars' worth of colts (see fig. 1). These accounts

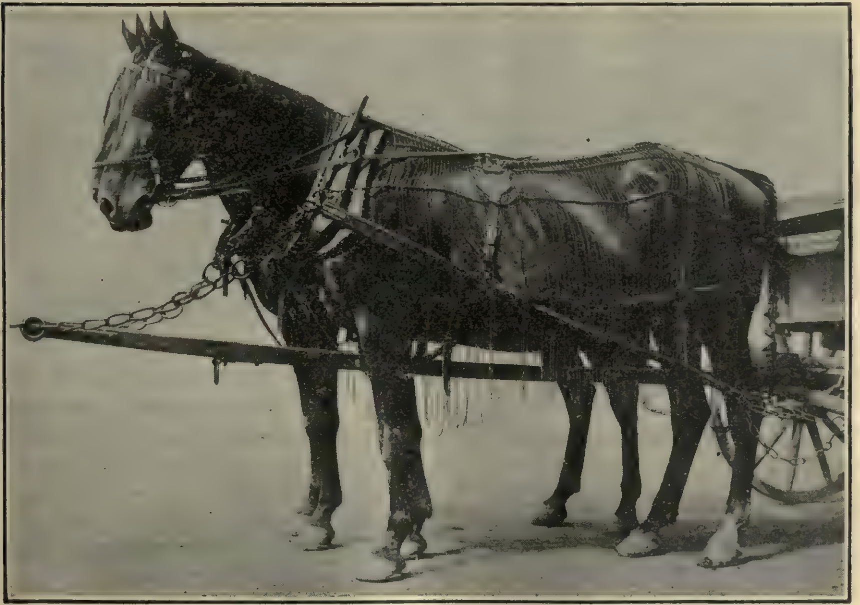

FIG. 1.—A profitable mare. The near mare in this team besides doing more than enough work to pay for her feed has produced 11 live foals. Before producing her first foal she was used for three years in livery work. Her offspring have sold for good prices.

seldom tell of more than one such mare on a particular farm, whereas to obtain the greatest returns nearly all the work animals maintained on the farm should be mares of this character.

Breeding the working mares places double duty on them, consequently they must be robust individuals properly conformed and must be given good care and treatment. With two sources of profit from one animal, farmers can well afford to pay more for such stock, feed it more heavily, and give it special attention. The small farmer is the one who is most likely to get the best results from such a plan, because he usually works his own teams or is in a position to watch them closely and see that they are not ill-treated.

SELECTING BREEDING AND WORKING MARES.

The two outstanding requirements in profitable farm mares are that they be breeders and workers. If a good registered stallion is available, pure-bred mares of the same breed will probably give better returns than grades. It costs practically no more to raise a pure-bred colt than it does to raise a grade, and the returns are much greater. The amount of capital that can be invested in the mares would be an important factor in determining whether pure-breds should be used. Any mare that is not at least a high-grade should not be considered. The particular breed that the pure-breds or grades should conform to would depend largely on local markets. Some communities are noted for and attract buyers of high-class drafters; others have local dealers who handle many choice harness horses, and still others have a steady outlet for saddle horses; consequently in a locality favored with any such markets it is generally advisable to breed the prevailing type, since by so doing sales are more easily made and the services of high-class stallions are practically assured.

However, some persons have a decided preference for a particular breed or type, and where this is so a greater success often will be made in raising the kind naturally preferred, although it must be remembered that it is difficult to show a profit when raising something for which there may be little or no demand. It is generally accepted that light horses are best suited to rolling and semimountainous land, while drafters are more adaptable to level country.

UNIFORMITY OF THE MARES.

The uniformity in the mares kept on a particular farm generally is not given much consideration. There is satisfaction and convenience in having mares similar enough in type and action so that one can readily fill the place of another at any kind of farm work. Such mares are especially desirable when it is necessary to work three or four abreast, as shown in the illustration on the first page of this bulletin. In case four are needed to a wagon, it is a good advertisement to the owner's judgment and ability as a horseman to have them all uniform, in good condition, and hooked up to a nicety. If the mares resemble each other and are bred to the same stallion it will often be possible to sell the young horses as pairs, in which form they nearly always sell at a premium. The market for horses bred in this manner will not be overcrowded very soon, as readily will be attested by anyone who has been confronted with the difficult task of purchasing from farmers mated pairs of a certain type.

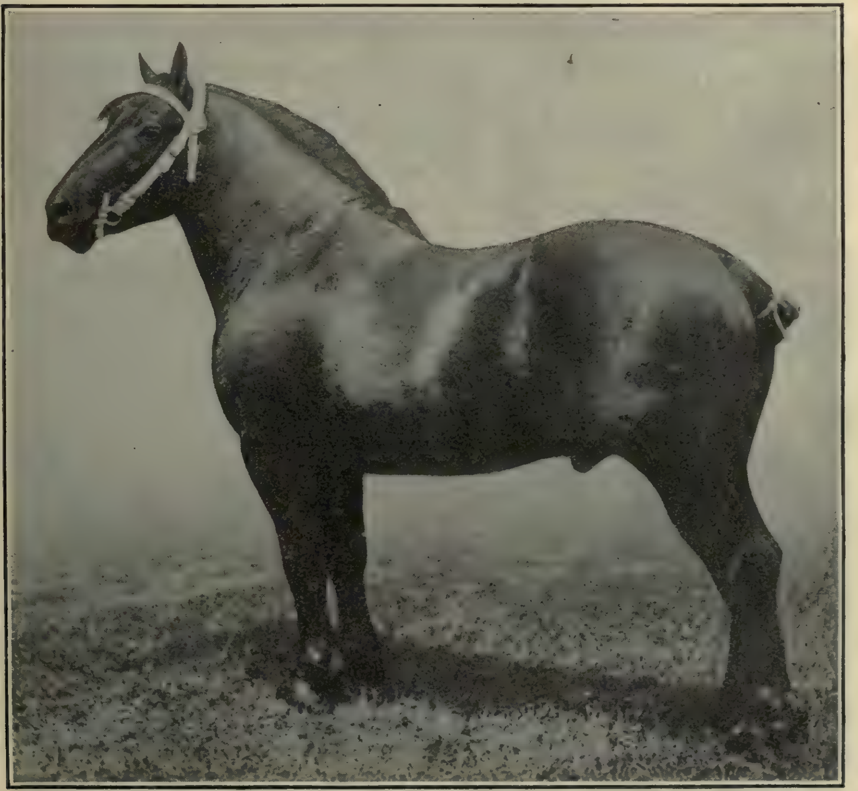

FIG. 2.—Draft stallion showing weight, long croup, short, smooth coupling, and well-sloped shoulders; the head denoting intelligence and refinement.

DESIRABLE CONFORMATION OF MARE.

Breed characteristics in pure-bred or grade mares signify impressive ancestry and prepotency. Feminity of expression and conformation is an indication of good breeding qualities. Style, good disposition, quality, clean, flat bone, concave open feet, strong constitution, good proportions, deep, roomy barrel, width across the hips, denoting a large pelvic arch, and well-developed vulva and teats are qualities especially desired in breeding mares. An inspection of the colts the mare produces is the best evidence of her worth as a brood mare. The length of usefulness as producers varies greatly with different mares. Some will produce excellent colts when 25 years of age, but if they produce until they are 15 years old they do very well. Much depends on the individuals and the way they are handled. Shy breeding mares are generally unprofitable producers.

SOUNDNESS.

Unsound horses lose breeders much money, consequently it is of great importance that all horses reared should be as sound as possible. Horses become unsound because the tissue or the structure (or both) at a particular point is weak, or else the strain exerted on the part is greater than the best tissue and the best conformation could stand. Of course, if bad conformation exists, it is agreed

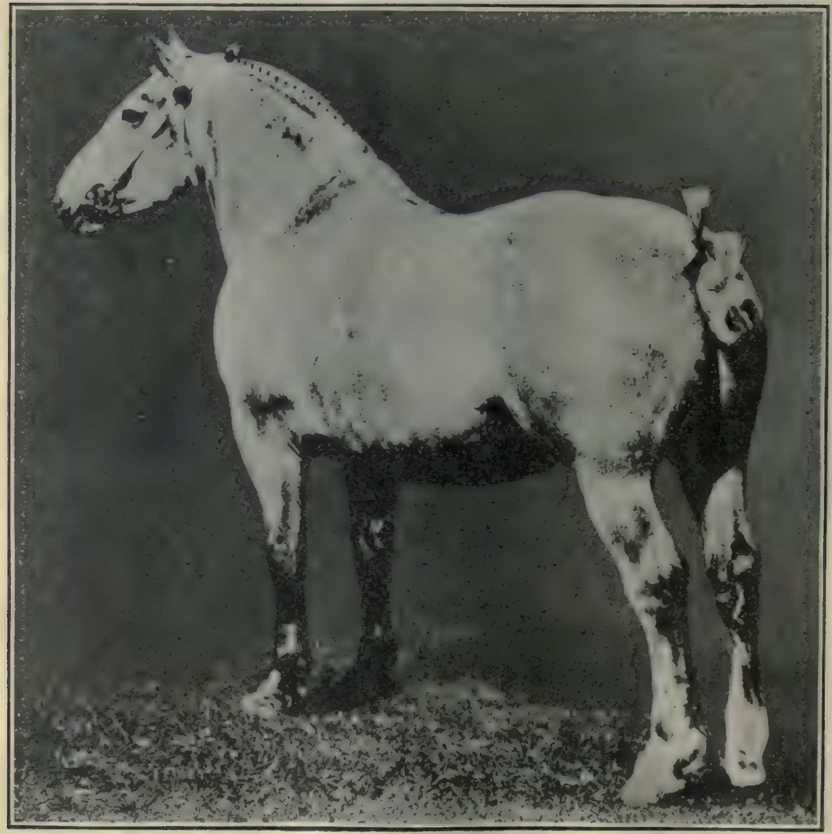

FIG. 3.—Draft mare of desirable conformation. This mare possesses substantial underpinning, substance, compactness, and style.

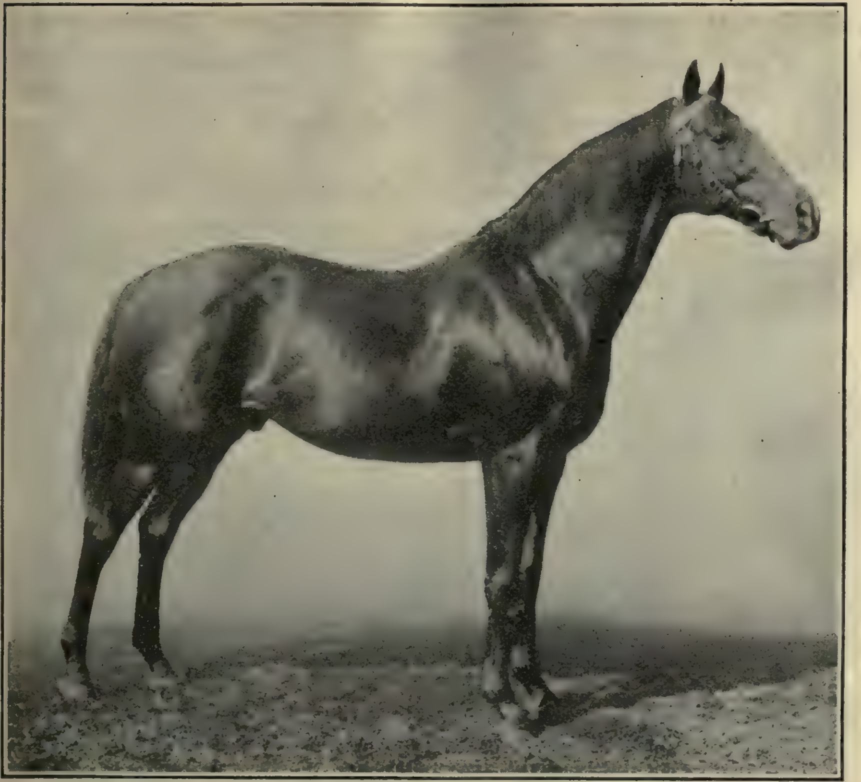

FIG. 4.—Light stallion with well-set limbs, substance, and quality.

that animals thus built should not be used for breeding purposes whether they are sound or not. When considering horses that are unsound but apparently have good conformation, it usually is difficult to decide whether the conformation is at fault or whether an unbearable strain was the cause; consequently these, too, should not be used as breeders unless it is positively known that the unsoundness developed after severe labor had been performed in amount or degree much greater than that performed by the average horse.

The following kinds of unsoundness are regarded by the Bureau of Animal Industry as sufficient to bar a mare from being bred to a Government stallion: Bone spavin, ringbone, sidebone, heaves, stringhalt, roaring, periodic ophthalmia (moon blindness), and blindness, partial or complete. This list is used principally in the Army horse-breeding work and was compiled in consultation with the members of the American Veterinary Medical Association and practical horsemen throughout the country. Some latitude is allowed the officers of the bureau in its enforcement. Blindness or lameness, for example, positively known to be due to accidental causes, usually would be passed. In the cases of stallions, a more strict standard of soundness generally is followed than with mares. The stallion registration laws of various States usually prescribe the unsoundnesses which bar stallions from public service. Some States have a longer list than others. Without discriminating, however, the list given above is one on which horsemen generally will agree. The unsoundnesses there given are the most common and are detected readily. The elimination of unsound breeding stock, the feeding of balanced rations that will insure proper development of bone and other tissues, and the use of precautions in the handling and management of the colts are the right steps to take in eliminating unsoundness from horse stock.

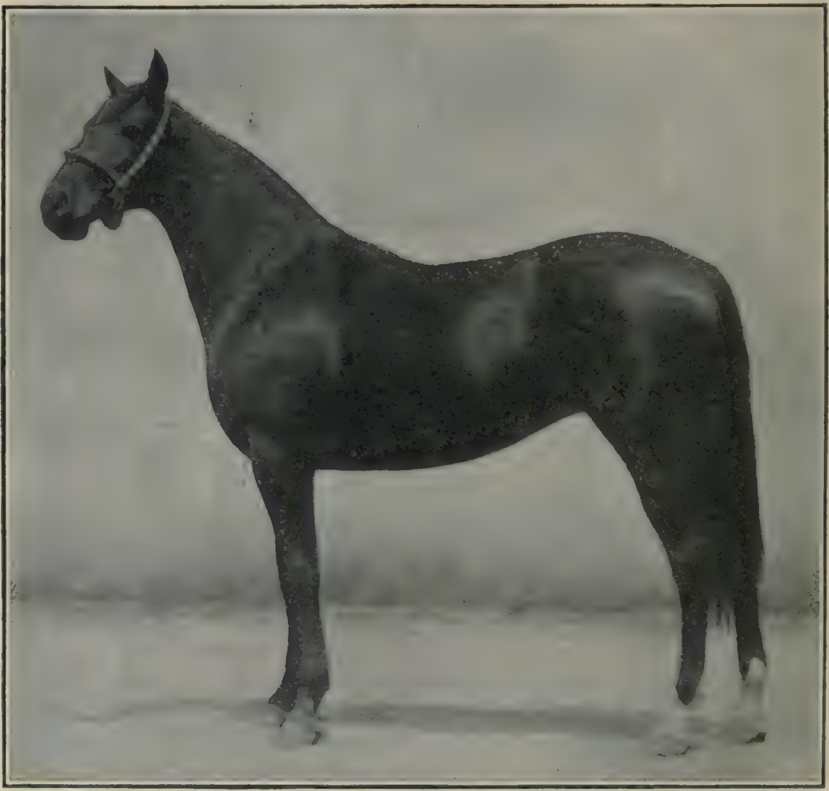

FIG. 5.—Light mare of desirable conformation. Quality, smooth lines, animation, and indications of strong constitution are evidenced.

SELECTING A STALLION.

A low service fee never should tempt one to use an inferior stallion. It also may pay better to use a stallion which stands at some distance rather than one that is more convenient. While the cost of a stallion is not always in proportion to his worth as a sire, the service fee generally is if the horse has been standing long enough for mare owners to be able to pass judgment on his prepotency and on the quality of the colts he gets. The opinion of disinterested horsemen together with the stallion's show winnings will aid in making a good selection. Weight is an indispensable quality in a draft stallion, although it should not offset a deficiency in other respects. In the lighter stallions style, smooth lines, and swift, well-balanced action are necessary to improve the light horse stock. In any breed good feet, clean, flat bone free from meatiness, well-defined hocks, good disposition, quality, animation, and breed characteristics are well worth looking for in the sire. It is poor policy to use anything but a sound pure-bred stallion free from manifest faults of conformation and of the same breed or type as the mare. It must be borne in mind, too, that a stallion that is not properly fed and exercised is not likely to get a large proportion of strong, healthy colts. In short, too much care can not be exercised in securing a suitable mate for the mares, and the fundamental law that generally holds in all breeding operations must always be remembered, viz, like produces like or the likeness of an ancestor.

MATING CONSIDERATIONS.

Only very well-developed draft mares should be bred at 2 years of age. All others should go until 3 years, and some even until 4 if they are not strong or are slow in maturing. If bred at 2 years of age they should not be bred during the third year, thus giving a chance for further development. Mares conceive most readily about 9 days after foaling, and after this they generally come in heat about every 18 to 21 days until they become pregnant, but this varies a great deal even with the same mare. Some mares fail to show signs of being in heat even when tried regularly with a stallion, but such mares usually can be made to want the services of a stallion in a few days by giving them either a forced service or by opening them up with the hand which has first been thoroughly cleansed. To take the mare to the stallion divides the work up better than to expect him to hunt up each mare. Better accommodations are afforded at the stallion's stand for teasing and serving mares, and accidents are less likely to occur. The mare will react at breeding time more surely if she is in a healthy, vigorous condition. Extreme fatness interferes with the mechanical and physiological performance of the reproductive organs, while thin or weak mares do not readily catch. The mare should be given plenty of time to rest after she gets to the stallion, and she should be tied close to him. Very often there is too much hurry, so that the mare is forced to take the service before she is just right. If the weather is cold, warm the mare up by exercise, but do not breed her when extremely hot or fatigued.

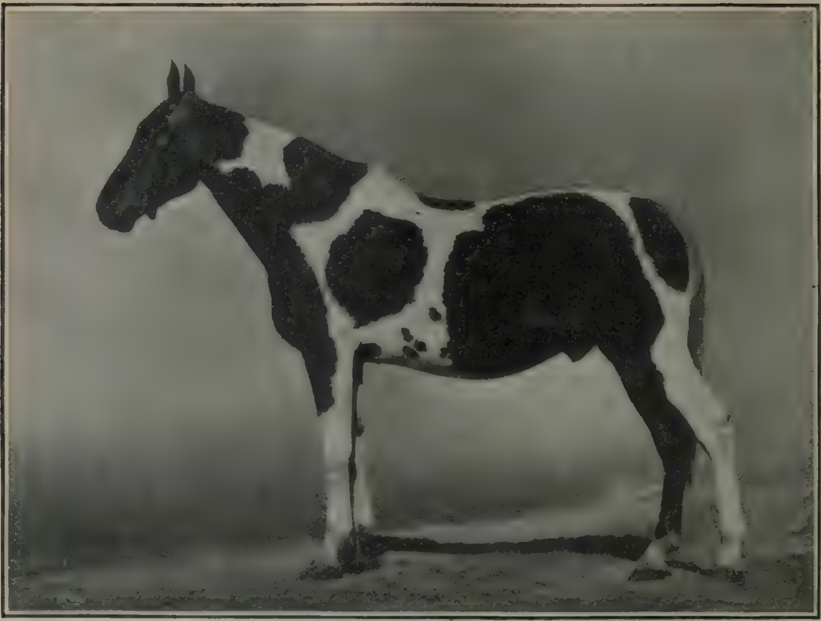

FIG. 6.—A spotted stallion of inferior breeding with undesirable hind legs. The offspring of this horse do not find a ready sale because of their color and crooked hind legs.

Mares with unnatural discharges from the vagina are usually hard to get in foal. Before the stallion is allowed to make the service such mares should be washed out with a warm 2 per cent solution of a good coal-tar disinfectant and then be flushed out with clear warm water that has previously been boiled. These precautions not only aid in foaling the mare but also eliminate the chance of spreading an infection. It is still better to breed such mares artificially after the organs have been cleansed as just directed, using the breeding bag in the mare or on the stallion. Artificial services also will aid in settling shy breeders, and no harmful results will follow such a method of breeding provided the operator's hands are thoroughly cleansed and the finger nails are short.

Considerable responsibility rests with the owner of the mare in seeing that she is returned to the stallion every 18 to 21 days to be tried and rebred if necessary. This is absolutely necessary in order to get a large per cent of mares in foal. If the mare is accustomed to dry feed she should not be turned on pasture soon after breeding. Besides thus changing her feed, she may be annoyed by other horses. Hard work immediately after breeding may also hinder a mare from getting in foal.

Records should be kept of the breeding of each mare in order that the approximate time of foaling may be known. The period of gestation of the mare is from 330 to 360 days. This period varies widely, but preparation should be made for the arrival of a foal at the end of 11 months. The natural time for foals to come is in the spring, when the air is warm and there is grass, sunshine, and an opportunity for range and freedom. Modern farming methods, however, especially in certain localities, have made it advisable to change nature's ways, consequently the farmer may find it better for the mare to be heavy in foal or suckling a foal in the fall, when the heaviest part of the farm work is over. Flies are not as troublesome in the fall as in the spring, and during the comparatively idle winter months the mare can give practically all of her energy to furnishing milk for the foal. By the next spring the young animal will be ready to turn on pasture, where it will require but little attention. However, fall foals can be raised successfully only when special care and feed are provided during the first winter, and where a warm, dry, light, and well-ventilated box stall can be furnished each mare and foal.

FEED AND MANAGEMENT OF MARES IN FOAL.

The mare will be healthier and the foal stronger at birth if she is used at slow, light work nearly every day. Also parturition will be easier. If it is not possible to work a mare, she should in the

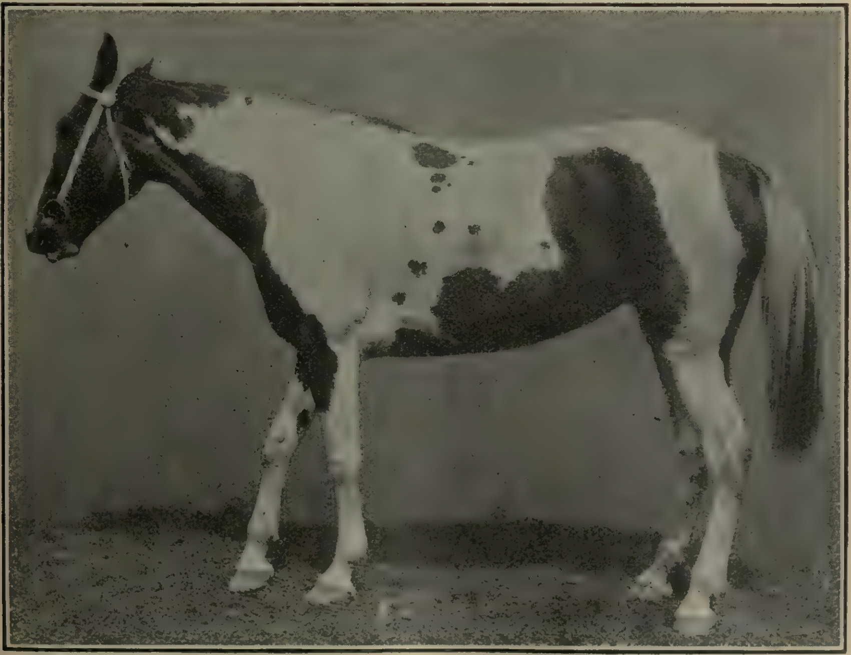

FIG. 7.—A mare from the stallion shown in fig. 6. Note the curby conformation of the left hind leg which is similar to that of the sire.

summer be turned in an open pasture, where she can get exercise, fresh air, and nutritious feed. Her feed should supply the demand for the maintenance of her own body and also for the development of the fetus. The ration, therefore, should contain a little more protein and ash than that demanded by a working gelding. The proportions of these should be increased slightly toward the last of the pregnant period. If the mare is idle in winter most of the feed may be roughage, but a heavier ration must be fed when work is done. The quantity of feed is determined by the size and condition of the animal, whether thin or fat, sick or well, by the appetite, by the amount of work done, by individuality, condition of the droppings, and whether the animal is easy or hard to keep.

GRAINS.

Oats is the best grain for the horse; it is a light, palatable, and balanced feed. Corn is a good grain, but is used to better advantage if it forms only from one-third to one-half of the grain ration of the brood mare. If wheat is fed, it must be given ground and in small quantities. Barley is a good horse feed; it is more bulky than wheat and nearer like oats than corn in composition. Barley is often cooked and fed once or twice a week in the evening for its medicinal qualities. Bran is an almost essential horse feed. It is a regulator and a preventive of overfeeding. It is bulky and pal-

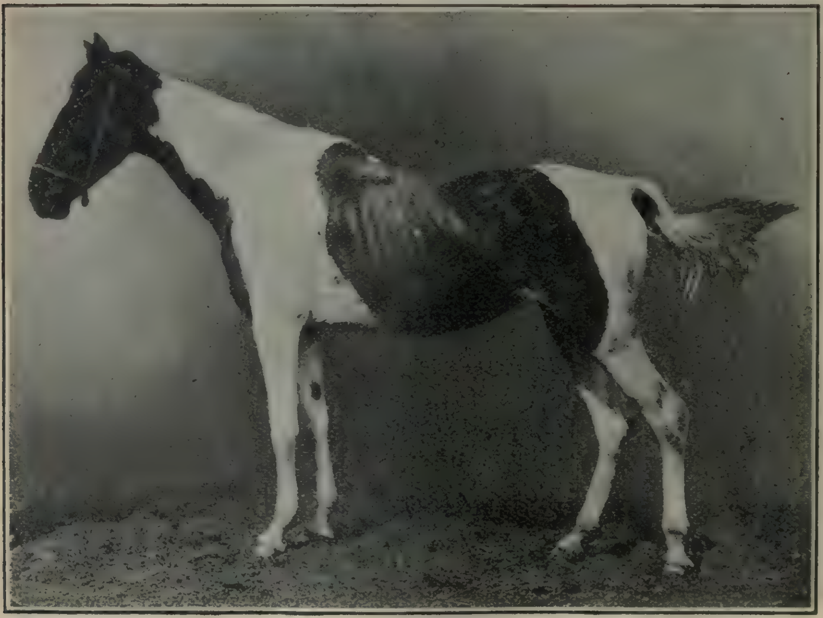

FIG. 8.—This mare was also sired by the spotted stallion shown in fig. 6. The color and crooked hind legs have been inherited from the sire.

atable and lightens the ration. Soy beans and cowpeas are relished by horses, and when accessible will serve as a useful addition to the grain feed for mares in foal. They are relatively rich in protein, and consequently combine well with corn.

ROUGHAGE.

Timothy hay is a popular roughage for horses. Brome grass makes good hay which is equal to timothy hay in feeding value. Orchard grass, if cut in early bloom, is equal to the best of the hay grasses, and carries considerably more crude protein than timothy. Meadow fescue is not so valuable as timothy for horses. Sudan-grass hay is a safe feed for mares, and numerous native prairie grasses furnish hay that is equal to timothy. Clover hay is likely to be dusty, but it has great fattening qualities. Millet is not a safe feed for mares in foal. Corn fodder frequently is used to feed idle horses in the winter, but there is not enough nutrition in it alone for mares in foal. The same thing is true in a greater degree of straw. If either is fed, good-quality hay also should be fed. Unthrashed cowpea or soy-bean hay is also a valuable roughage which is relished by horses. Even the thrashed hay contains considerable nutrition. It should not be fed to brood mares if it contains any mold. Alfalfa hay makes an excellent feed for mares if it is fed once a day and timothy or corn fodder given at the other feeding. Occasionally alfalfa hay is not properly cured, causing it to mold badly, in which case it should not be fed to the horses. Farmers have reported occasionally that alfalfa causes the kidneys to act too freely, but it is likely that this trouble will not be noticed if the alfalfa does not make up over one-half of the roughage.

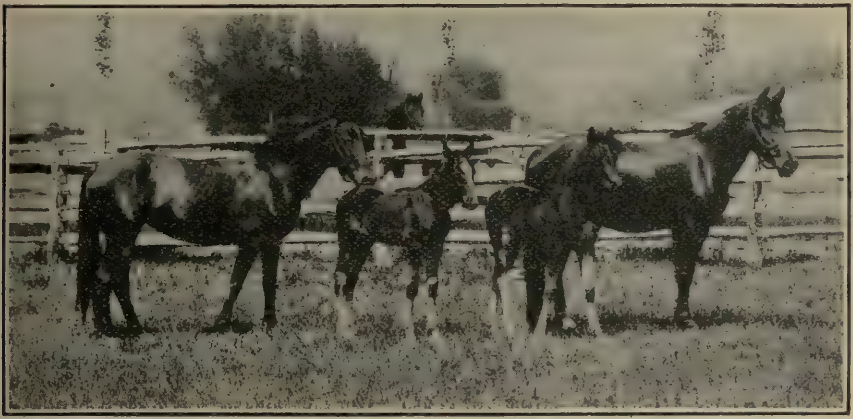

FIG. 9.—Brood mares and foals in desirable condition and showing the effects of good pasture. Aside from its high cost in some localities the post and rail fence shown is ideal for surrounding horse pastures.

SUCCULENCE.

Succulent feeds are those which are juicy, and are easily assimilated. Such feeds have a cooling, laxative effect on the digestive system and stimulate appetite. The most common succulent feeds on farms are grass, carrots, rutabagas, sugar beets, and silage. Grass, although of a succulent nature, is generally used as the entire ration through the summer if the mares are idle. If they are worked, grass usually forms a supplement to the hay and grain. Brood mares should be allowed access to grass whenever available, compliance being made with precautions later mentioned.

ABORTIONS.

Figures obtained from the United States Second Horse Breeding District show that in some localities as high as 7 per cent of the mares impregnated abort each year. It is quite possible that all abortions are not reported or are not known, in which case the percentage would be higher still. As abortions generally are due to kicks, strains, slips, squeezing through narrow doorways or partly closed gates, excessive riding, driving, or pulling, and improper or moldy feed (such as moldy corn fodder and heavily frostbitten grass), it is evident that American farmers are loosing many thousands of dollars yearly by careless and injudicious handling and management of their brood mares. Furthermore, breeders often have difficulty in getting in foal a mare that has previously aborted, so that the loss may be a far-reaching one. If of the contagious character, abortion may turn a profitable band of brood mares into a practically valueless one so far as breeding ability is concerned.

To recapitulate, proper feed of sufficient quantity and variety, regularly supplied, uniform moderate work, and careful handling will maintain an in-foal mare in proper physical condition to develop a healthy, strong fetus.

APPROACHING PARTURITION.

Mares heavy in foal should not be taken from work suddenly, but should be kept in harness at light work (if already accustomed to it) until within a week or a few days of foaling time. A week or so before parturition there is a sinking of the muscles of the croup, falling of the abdomen, and filling of the udder. At this time the mare should become accustomed to being quartered in a sanitary, pleasant, quiet, light, comfortable, and roomy box stall. If not accustomed to pasture she should not be allowed it at this time, but should be given exercise in a dry lot after she is no longer worked. Moderate exercise is desirable, and occasionally it is necessary to have a sluggish, idle mare led a short distance each day in order that she may get sufficient exercise. Too much exercise at this time is just as detrimental as not enough, and a knowledge of the mare's previous success in delivering a foal, coupled with judgment, will determine the nature and amount of exercise as well as feed, etc., that should be allowed. Wax and sometimes milk will be found on the teats a day or so before foaling. Idle mares frequently develop an udder a longer time before parturition than mares that are worked regularly.

PARTURITION.

Indications of immediate parturition are uneasiness, lying down and getting up, switching the tail, and biting the sides and flanks. If possible be present when the foal comes. Many mares, of course, will not bring forth their young (if able to keep from it) while they are being watched, but it usually is possible to hide quietly in an adjoining stall until the foal is delivered. Parturition generally lasts 10 to 15 minutes; if it extends to 4 or 5 hours the colt will come dead. In normal presentation of the fetus, either the fore limbs extended with the head resting on them or the hind limbs extended will first make their appearance through the vulva. Any other presentation may be attended with difficult parturition, in which case a competent veterinarian should be summoned.

First after the foal is dropped see that it begins to breathe. Take the film of tissue from its nostrils, and if respiration does not start immediately blow into the mouth, work the ribs, and rub the body with a wisp of hay. Put the foal in one corner of the stall on clean fresh straw, and remove all the afterbirth and discharged fluids. Clean the stall thoroughly, scatter lime on the bare floor, and then cover it with clean bedding. The afterbirth should be burned or buried deeply with a thick covering of lime. It is one of the best mediums for bacteria of various kinds to develop in, hence it is essential to dispose of it properly.

Foals at birth usually weigh from one-tenth to one-twelfth as much as their dams.

Sunshine is a great enemy of disease germs, consequently plenty of light should be provided in the stables. A common but unhealthful practice, in sections where bank barns are prevalent, is that of having the box stalls located next to the bank side of the barn. Besides the lack of light in such stalls they frequently are damp, yet it is in such places that mares frequently bear their foals and the latter are housed. A window is inexpensive and will do much good in such cases.

CARE OF THE FOAL.

Foals should nurse after they gain strength enough to get on their feet and walk around. In the case of weak or very crooked-legged foals it may be necessary to assist them in getting to the teat, but often an effort is made to force them to nurse before they are ready. Nature takes its own time on such occasions, and hurrying and bustling may do more harm than good. Before the foal nurses, wash the mare's udder with a warm 2 per cent solution of a good coal-tar disinfectant and then rinse with warm water. The first milk which comes from the mare is known as colostrum and acts as a physic on the foal, causing the fecal matter in the intestines to be discharged; hence the folly of milking the mare before the foal comes merely because there appears to be too much milk in the udder. If the contents of the bowels are not ejected naturally within 24 hours, 2 to 4 tablespoonfuls of castor oil shaken in milk should be given, and it also may be advisable to inject warm water or 2 ounces of castor oil into the bowels. Repeat this treatment every 3 or 4 hours until the bowels move. Vaseline applied in the rectum may aid in ejecting subsequent dry matter.

To offset the danger of navel infection in foals (which causes a disease known as joint-ill), the navel cord should be washed several times a day by holding up around the cord a large-necked bottle which has been nearly filled with a 1 to 1,000 solution of corrosive sublimate (bichlorid of mercury), or by saturating the stump with full-strength tincture of iodin. Then dust it with powdered slaked lime. This should be repeated each day until the navel cord drops off. In case the navel does not dry properly or shows inflammation, a veterinarian should be called. Mares are inclined to be peevish or cross when with their young, consequently it is advisable to perform the foregoing precautions as speedily as possible, and then leave the stable so that the mare and foal can rest without being disturbed.

FEEDING AFTER FOALING.

The mare should not be fed heavy grain or hay for the first 24 hours after parturition and the first feeding should consist of a bran mash with a little cooked flaxseed meal in it. A little oatmeal soaked in warm water also is appropriate. If the mare is constipated give laxative feed. In 2 or 3 days, if doing well, she may be put back on dry feeds. In a week, if she is put back to work, she can have full feed. The mare may be put in harness, if light work is done, 2 or 3 days after foaling, but it is hard on the foal and may injure the mare's udder. It is best to turn the mare and colt in a lot where they can exercise and yet be quiet, but care should be taken at first to see the foal is not chilled by staying out too long in cool, disagreeable weather or by lying on cold, damp ground. They should not be on grass if the mare has not been on grass before.

In a little over a week the mare may be safely put to work provided she previously had been worked. If the foal is left in the stall, the mare should be brought to the stable in the middle of the forenoon and afternoon in order that the foal may get its food, but in no case should a foal suckle a mare that is very warm, as digestive disorders are likely to follow. If possible, do not use the mare for purposes which will keep her away from the farm for a long time, as the foal will either go too long without nursing or else will be worn out by following the mare. When left at the stable the foal should be kept in a roomy, clean box stall in company with another one of about the same age if possible.

At about 2 months of age the foal will take dry feed, which should be supplied through the dam's grain box. This makes it necessary to furnish her with such feeds as ground oats, corn meal, and bran. A little later on a "creep" should be built in the stall or pasture, inside of which the foal can be supplied with grain without having to share it with its mother. A creep is simply a partition that will keep the mare out of the inclosure, but which is far enough from the ground so that the foal can walk under it. A handful of ground oats should be given at first, and the quantity should be increased slowly as the foal grows. The maximum amount should be about 1 pound a day till weaning time.

RAISING THE ORPHAN FOAL.

It is not uncommon for a mare to die shortly after foaling, thus leaving her foal dependent on artificial feeding for its sustenance; and some mares furnish an insufficient amount of milk for their colts. Cow's milk furnishes a most logical substitute for mare's milk, but as the composition is somewhat different, certain changes or modifications are necessary in order that the supplied diet be not too dissimilar from the natural. The following table of percentages gives the average composition of the two kinds of milk:

	Water.	Protein.	Fat.	Sugar.	Ash.
Cow's milk	87.17	3.55	3.69	4.88	0.71
Mare's milk	90.78	1.99	1.21	5.67	.35

Milk from as fresh a cow as possible and which is not rich in butter fat should be diluted about one-fourth with fresh water. A tablespoonful of sugar and about 3 teaspoonfuls of lime water should be added for each pint. This mixture should be supplied to the colt at about body temperature. A bottle with a rubber nipple, or even a finger of a kid glove with a fair-sized hole in it fitted over the end of a spout of a vessel such as a teapot, will serve as a convenient utensil in getting the foal to take the milk. If the finger of a kid glove is used it should be as clean as possible. At first about one-half a cup of milk should be given every hour, the quantity to be increased slightly and the intervals to be lengthened gradually as the foal grows older. In about 2 months skimmed milk may be substituted for whole milk, and in addition one of the following rations should be fed: One part of flaxseed meal boiled to a jelly, and 2 or 3 parts of bran. Or 2 parts ground oats, 1 part corn meal, and one-half part flaxseed meal. Or 2 parts of bran, 2 parts corn meal, and 1 part oil meal. Feed a double handful a day to start with, and increase the amount gradually.

Raising a foal by hand is not a job for the careless and indifferent. It requires patience, painstaking care, perseverance, judgment, and cleanliness. The vessel in which the milk is supplied should be scalded thoroughly each time it is used. Unclean receptacles for the milk and irregular intervals for feeding likely will cause scours. The quarters should be very clean and the orphaned foal should have company of some kind. Another foal is desirable, but even a calf is better than no company. A grassy paddock with abundant shade, fresh water, and protection from flies will increase the orphan's chance of proper development.

SCOURS.

A most common cause of scours in foals is when they get too much milk at irregular intervals; consequently better management is the first step in remedying the trouble. Castor oil often is used to check scours, 1 or 2 ounces being the dose for young foals. Raw eggs also are used successfully. Blood meal is considered one of the best remedies, the quantity used being one-tenth to one-sixth of the grain ration. Powdered tannic acid also gives quick relief, the dose being 5 to 15 grains. For other than a mild case a competent veterinarian should be consulted.

WEANING.

Foals belonging to mares that work hard should be weaned earlier than those belonging to mares which are practically idle. While most foals are weaned when about 5 or 6 months old, it is well to remember that it is economical to feed a foal through its mother. However, in case the mare is again in foal, if she is allowed to nurse for over 6 months it may decrease the vitality of the next foal. If the foal is getting plenty of nourishment from grain, grass, and roughage, it will not be seriously set back when shut off from its dam's supply of milk. When taken away from its mother it should be placed with another foal of the same sex and age in an inclosure where they can not possibly get out or become injured. Feeding grain is not absolutely necessary if the foal is on good grass and previously has been accustomed to it, nevertheless it has its advantage, especially with draft animals. Foal feeding always should be practiced with foals belonging to mares that are worked.

The foal should not nurse more than once after it has been taken away. The excess milk from the mare's udder should be taken from 3 to 5 times a day, but enough should be left so that her system will start to absorb the milk, otherwise the drying-up process will be delayed unnecessarily. Not withdrawing sufficient milk will cause the udder to cake and spoil. Vaseline or lard rubbed on the udder will aid in keeping it soft.

FEEDING AND MANAGEMENT OF YOUNG HORSES.

CARE AND FEEDING DURING FIRST WINTER.

Colts can be housed satisfactorily either in the stable or in an open shed. The shed shown in figure 10 is practicable where it is necessary to provide shelter for several head. The main requirements are that the quarters be dry, sanitary, and provide fairly warm protection from winds. Several foals may run together if the weaker ones are not driven away from their feed by the stronger. The quarters should be kept clean and well bedded and occasionally should be disinfected. Lice are to be suspected when the animals get to rubbing and lose patches of hair. Thorough washing with the proper solutions of coal-tar disinfectants will kill lice. It costs money to feed lice, consequently efforts should be made to keep them down. The foals should be out in the open every day that is not stormy; it is harmful, however, for them to remain out in a cold rain. The foal should be taught to lead and to stand tied during the first winter.

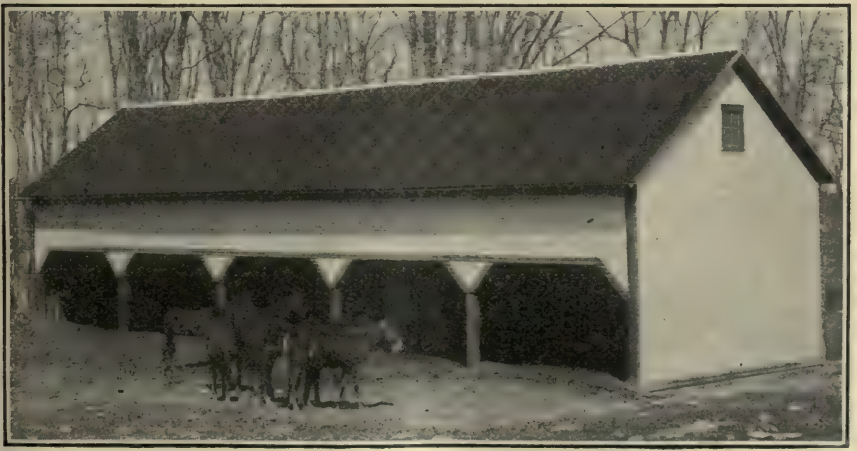

FIG. 10.—A shed open on the south side. A desirable place in which to winter colts unless the climate is too severe.

Feeds that will promote growth should be supplied. Good, clean clover hay is palatable and slightly laxative. Timothy hay commonly is fed. Well-cured alfalfa hay free from dust is one of the best roughages for growing, but because of its relatively high protein content it generally is economical to supplement it with other roughage such as timothy, mixed hay, or corn fodder. Besides lending variety to the ration such a method of feeding alfalfa would offset any likelihood of kidney or bowel irregularities. Sheaf oats can be used to advantage to supplement other roughage. The animals should not be allowed to gorge themselves on dry feed. They should be given only what they will clean up readily, but at the same time enough feed should be supplied. Oats, corn, and peas, preferably fed ground, are suitable grains. Bran, oil meal, or gluten feed will add protein and lend variety. Cottonseed meal should not be fed to foals. Appropriate grain rations for the first winter are: 2 parts corn, 5 parts oats, 3 parts bran, and 1 part oil meal; or 4 parts oats, 1 part corn, and 1 part bran.

Silage should not be fed to foals to any considerable extent. Sliced roots, such as carrots and sugar beets, are very palatable and have a cooling effect on the digestive system. The quantity of feed generally should be regulated by the appetite, although occasionally the appetite may be too ravenous to be a good indication. The general condition of the colt and the droppings should be observed daily. Usually not over 1 pound of grain per 100 pounds of live weight should be fed until the animal is 2 years old. A liberal supply of salt and good water and plenty of fresh air and exercise are essential for the proper development of young horses. Idleness succeeding exercise will cause constipation. It is often said that a horse is made during his first winter. Certainly this is a critical time in the animal's life, and at no other age will proper feed and attention do as much to make of him a good horse. If stunted during the first winter he never will gain proper size and shape.

FEED AND CARE DURING THE SECOND SUMMER.

Foals should be changed from dry feed to pasture gradually, and should not be turned on pasture until the grass is old enough not to become washy. Grass is an indispensable factor in the economical and proper physiological development of young horses. Frequently in protected blue-grass mountain valleys they thrive the year round on pasture alone. A visit to the foal pasture every few days may be the means of early discovering sickness or injury. The feet of the young animals should be noticed on such visits, and if the hoofs are too long or high on one side they should be trimmed properly. A failure to keep the feet level may result in cracked hoofs or crooked joints. Barbed wire should not be used for fencing the pasture;

smooth woven wire is best. If a colt should be cut, disinfect the wound; and if it is a very large one, have it sewed up. The wound should be dusted frequently with boric acid or air-slaked lime until healed, and then greased with vaseline so the hair will grow properly. The animals should have plenty of fresh water and salt, and in hot weather they require shade.

CARE AND FEEDING DURING SECOND WINTER.

During the second winter the feed and management should be nearly the same as for the first winter, except that the quantity of feed should be increased somewhat, the colt tied up in his stall, and handled frequently. Education by gentle and careful but firm handling at this age will save later much strenuous labor. In this connection Farmers' Bulletin 667, "Breaking and Training Colts," should be consulted.

THE 3-YEAR-OLD.

The succeeding years are largely a repetition of those already discussed so far as feed and management are concerned, although the quantity of feed must be gradually increased as the animal grows. The prime general essentials for the proper development of horses from the yearling stage until they are put to work are: Fresh air, pure water, plenty of exercise, nutritious, palatable feed in sufficient quantity, and shelter from severe weather.

SUMMARY.

Good breeding is absolutely essential to the production of marketable horses which will bring top prices, but good breeding must be supplemented by proper feeding and management if the finished product is to be satisfactory. Figures collected at the Chicago stock yards show that flesh on high-class draft horses is worth about 25 cents a pound. It is worth equally as much on high-class horses of the lighter types. Certainly, then, it is more profitable to give the colts the good feed produced on the farm than to sell such feed and attempt to keep the colts and mares on the unsalable trash. Poor feed in scant quantity makes ewe necks, waspy waists, cat hams, starey coats—in short, an unsalable horse.

Horses always are needed to do farm work as well as for other purposes, and generally they can be raised from farm mares more cheaply than they can be purchased, while the surplus, if of proper breeding and liberally fed on suitable, balanced rations, will find ready sale at good prices because they will have the characteristics that suggest the ability to do work satisfactorily and profitably.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO HORSES.

AVAILABLE FOR FREE DISTRIBUTION.

Principles of Horse Feeding. (Farmers' Bulletin 170.)
Horseshoeing. (Farmers' Bulletin 179.)
Breeds of Draft Horses. (Farmers' Bulletin 619.)
Breaking and Training Colts. (Farmers' Bulletin 667.)
How to Select a Sound Horse. (Farmers' Bulletin 779.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Classification for American Carriage Horses. (Bureau of Animal Industry Circular 113.) Price, 5 cents.
Osteoporosis, or Bighead of the Horse. (Bureau of Animal Industry Circular 121.) Price, 5 cents.
Suggestions for Horse and Mule Raising in the South. (Bureau of Animal Industry Circular 124.) Price, 5 cents.
The Preservation of Our Native Types of Horses. (Bureau of Animal Industry Circular 137.) Price, 10 cents.
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The Army Remount Problem. (Bureau of Animal Industry Circular 186.) Price, 5 cents.
The Use of Energy Values in the Computation of Rations for Farm Animals. (Department Bulletin 459.) Price, 5 cents.
Dourine of Horses: Its Causes and Suppression. (Bureau of Animal Industry Bulletin 142.) Price, 15 cents.
Stallion Legislation and the Horse-Breeding Industry. (Yearbook Separate 692.) Price, 5 cents.
Horse and Mule Raising in the South. Price, 5 cents.
The Road Horse, with Special Application to His Selection and Management in Rural Delivery Service. (62d Cong., 2d sess., H. Doc. 906.) Price, 5 cents.
Special Report on Diseases of the Horse. Price, $1.

APHIDS INJURIOUS TO ORCHARD FRUITS, CURRANT, GOOSEBERRY AND GRAPE

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FARMERS' BULLETIN 804

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. April, 1917

APHIDS are small, delicate, winged or wingless insects which feed upon plant juices, draining them from the foliage, fruit, twigs, or roots, through a beak pushed into the plant tissues.

Many kinds injure orchard fruits, currant, gooseberry and grape. The most important are discussed in this bulletin.

Contact sprays, such as kerosene emulsion, soap washes, nicotine solutions, etc., must be used to kill aphids. Directions for preparing and applying them will be found on pages 34–39.

Stomach poisons, such as arsenate of lead, Paris green, and other arsenicals, are of no use against aphids.

Species which winter in the egg stage on the plants to be protected may be sprayed early in the spring as the buds are expanding, to kill the first brood and insure against injury later in the season.

Leaf-curling species, especially, should be treated with this bud spray in years when they are expected to be abundant. They can not be reached satisfactorily after the leaves have unfolded and the aphids have begun to be troublesome.

Those species which do not curl the leaves may be controlled readily by sprays when they are noted as becoming numerous.

Annual bud spraying in the case of the apple appears to be good orchard practice and, continued for a series of years, doubtless would prove profitable.

APHIDS INJURIOUS TO ORCHARD FRUITS, CURRANT, GOOSEBERRY, AND GRAPE.[1]

CONTENTS.

	Page.
Aphids in general	4
Apple aphids	5
Quince aphids	18
Pear aphids attacking the foliage	18
Plum aphids	19
Cherry aphids	22
Peach aphids	25
Currant and gooseberry aphids	27
Grape aphids attacking the foliage	32
Natural enemies of aphids	33
Control measures	34
Spray formulas	35
Spraying for apple aphids	39
Control of aphids on plum, peach, cherry, etc	40
Destruction of winter eggs	41
Control of aphids on currant, gooseberry, and grape	41
Clean culture	42

The control of aphids, or plant lice, is an ever recurring problem to the grower of orchard and bush fruits. Although cereal and forage crops furnish perhaps the most striking examples of the destruction wrought by aphids, practically no crop is free from attack by one or more of these small and delicate insects. During the past decade especially, aphid injury to orchard fruits, particularly the apple, has been on the increase.

The present bulletin treats of the aphids injurious to fruit and foliage of apple, quince, pear, plum, cherry, peach, currant, gooseberry, and grape. Thirty-two species of aphids in all are discussed. The more important forms affecting a given fruit are considered first, and then follows a brief account of species known to infest the plant locally or occasionally, and which growers should be able to distinguish from the more destructive species. In their life history aphids are peculiar in many respects, and each species occurs in several different forms; for this reason a short account of aphids in general is given for the information of readers not familiar with these facts. Remedial measures are described at the close of the bulletin, since similar treatments are applicable, with some variations, for the control of all the species considered.

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[1] Since the well known grape phylloxera [*Phylloxera vitifoliae* (Fitch)] is injurious principally to the roots and requires control measures radically different from those employed against foliage-inhabiting aphids, it is mentioned only incidentally in this bulletin, although its galls on grape leaves are illustrated (fig. 23, p. 32).

NOTE.—This bulletin is of interest to orchardists, vineyardists, and growers of currants and gooseberries in all parts of the United States.

APHIDS IN GENERAL.

Aphids, or insects of the family Aphididae, have a development which is remarkable in several ways. Eggs laid in the autumn hatch in the spring about the time when vegetation revives. From these winter eggs is produced a generation of females, usually wingless, which reproduce without the intervention of males (agamic reproduction), many species giving birth to living young. The adult aphids of the first generation are termed stem-mothers. The offspring of the stem-mothers (second generation) may be winged or wingless, or both forms may occur. They reproduce without the intervention of males, some species being oviparous, or egg laying, and depositing eggs which do not require fertilization for development, while others are viviparous—that is, they bring forth young alive, the eggs developing and hatching within the body of the parent.

A succession of generations may be produced in this way until the approach of autumn, when the true sexes appear and the females deposits eggs; or a species perhaps may be more or less biennial, some individuals producing true sexes only every second year. In still other species, the true sexes of which are at present unknown, reproduction without the intervention of males continues for a series of years.

The same species of aphid usually exhibits several forms, as wingless agamic females, winged agamic females, and the true sexual forms. In the last the male may be winged and the female wingless, or both sexes may be wingless. The different generations of a given species may vary more or less in appearance, and in some instances this is the case to such an extent that they appear to belong to distinct species.

Aphids feed upon sap which is sucked up through a beak pushed down into the tissues of the plant. Their presence on plants frequently is indicated by a curled and distorted condition of foliage, though this is not always so. When the insects are abundant the drain upon the plant is very great, interfering with its proper growth and development, and in extreme cases causing the death of infested parts. The leaves and shoots of plants infested by aphids are frequently seen to be covered with a black substance, as if dusted with soot. This is due to a black fungus which grows on the "honeydew" excreted by the aphids and is not especially injurious, though often objectionable as marring the appearance of the plants and fruit. Honeydew may be produced in such quantities as to coat the leaves and is attractive to various species of ants and wasps, which are often seen attending the aphids or frequenting plants infested by them. The ants of themselves are not usually the cause of trouble but merely denote the presence of the aphids.

Since frequent reference must be made in the following pages to the different stages and forms of aphids, information concerning these is presented in summary form as far as present purposes require:

Winter eggs.—These are small, oval, and blackish, and occur on the twigs, around buds, under scales of bark, or elsewhere on the shoots or branches of the winter host plant.

Stem-mothers.—The aphids hatching from the winter eggs. They are the progenitors of the numerous generations which follow during the succeeding spring, summer, and fall.

Wingless viviparous females.—Wingless aphids which give birth to living young without the intervention of males.

Winged viviparous females, or migrants.—Winged aphids which give birth to living young without the intervention of males and which migrate to other plants, establishing new colonies. Spring migrants and fall migrants are often to be distinguished.

The true sexes.—Males and sexual females are usually developed in the fall from the viviparous forms, the female depositing eggs to carry the species over the winter.

APPLE APHIDS.

Three or four species of aphids commonly attack the fruit and foliage of the apple, while a few more, which at present are of minor importance, are known to infest this plant. The important species to be considered are the rosy aphis, the green apple aphis, the woolly aphis, the oat or European grain aphis, and the clover aphis.

THE ROSY APHIS.[1]

The rosy aphis infests especially the foliage surrounding the blossom or fruit clusters, and causes the leaves to curl badly. (Fig. 1; fig 2, *b;* illustration on title-page.) The insects when abundant also infest the fruit stalks and newly set fruit. The little apples on the infested fruit spurs often fail to thin out, remain small, and as the season progresses become knotty and distorted according to the degree of infestation. In the fall these "aphis apples" (fig. 3) may be much in evidence, especially on the lower parts of the tree, during worst aphid seasons amounting to from 15 to 30 per cent of the crop. This species is very generally present in the apple-growing portions of the country and is at present the most important aphid pest attacking the foliage and fruit of this crop. On very young trees the feeding habits differ somewhat in that in addition to the foliage the aphids may attack the young shoots, causing these as they grow to become curled and twisted (fig. 2, *c;* fig. 4), resulting in permanent deformities which in pruning must be cut out in order that a properly formed tree may be produced.

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[1] *Aphis malifoliae* Fitch.

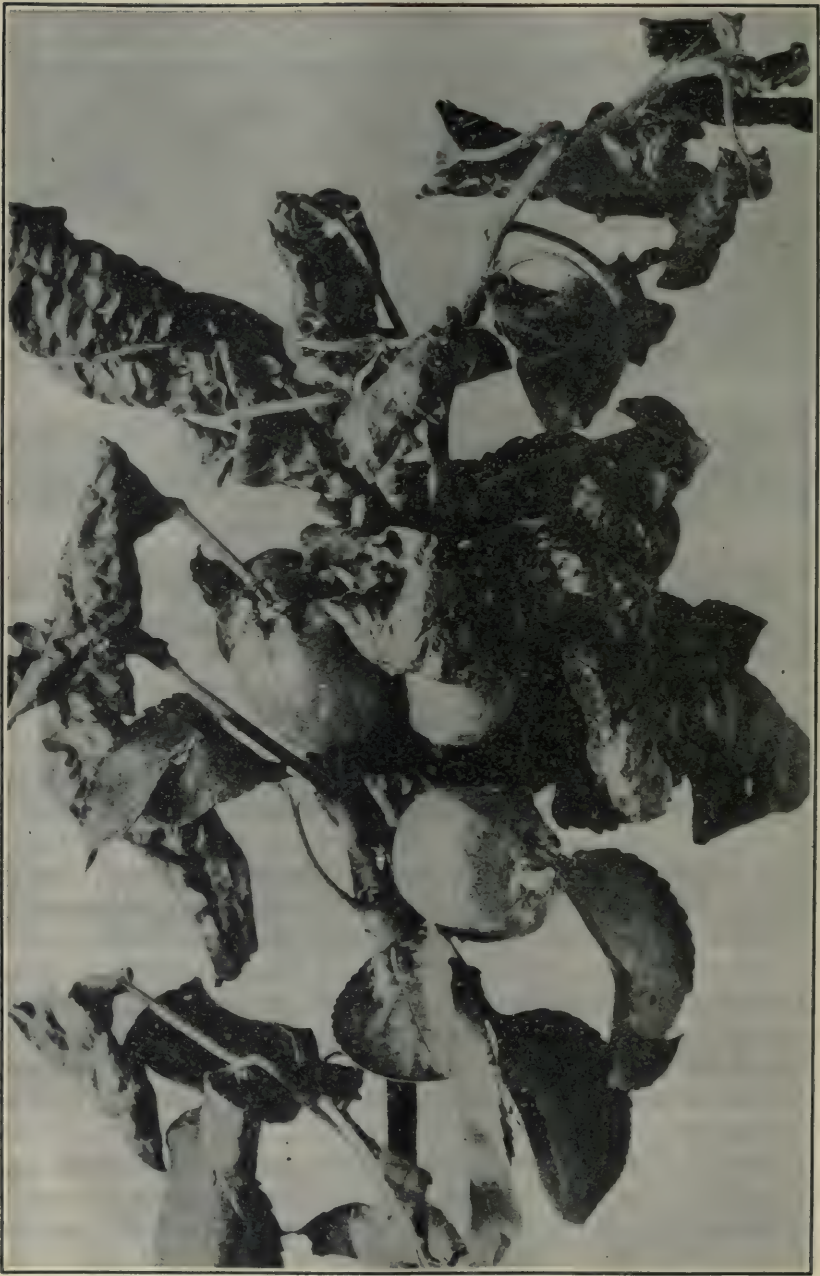

FIG. 1.—The rosy aphis: Injury to apple foliage and fruit. (Original.)

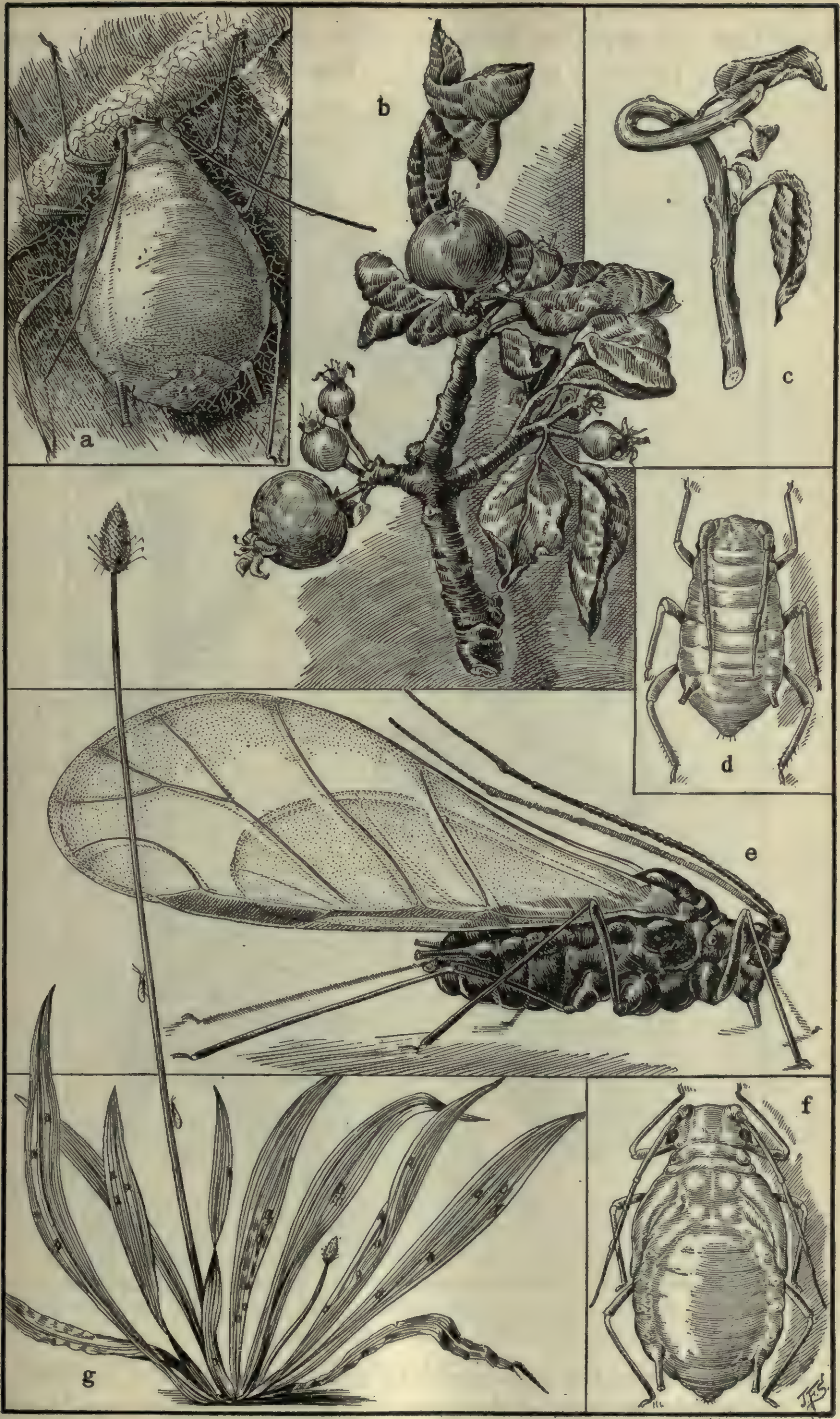

FIG. 2.—The rosy aphis (*Aphis malifoliae*): *a*, Wingless agamic female; *b*, injury to fruit and apple foliage; *c*, injury to apple twig; *d*, newly born agamic aphid; *e*, spring migrant; *f*, pupa of spring migrant; *g*, rib grass, one of the species of plantain on which the rosy aphis passes the summer. *a, d, e, f*, Greatly enlarged. (Original.)

The rosy apple aphis is easily distinguished from the other forms inhabiting the apple by its color. This varies from light salmon pink to deep purple or grayish black. The young stem-mothers when first hatched from the eggs are dark green, very similar in color to the young stem-mothers of the green apple aphis. The winged forms (fig. 2, *e*) are dark and often appear almost black, owing to the black head and body and the large black patch upon the abdomen. This

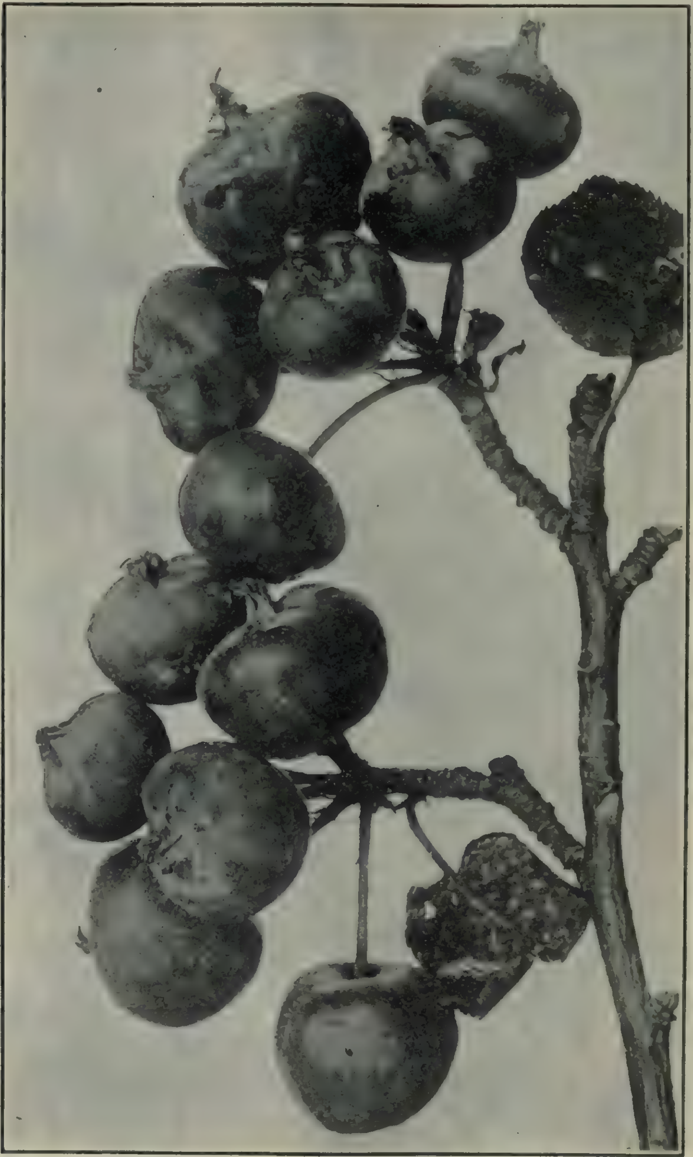

FIG. 3.—The rosy aphis: "Aphis apples." Note that the fruit has failed to thin out in the clusters. (Original.)

is particularly true of the fall migrants, which appear upon the trees in the fall. These produce the orange-yellow, wingless, egg-laying females. The males are winged and similar to the fall migrants. The summer forms occurring upon plantain are yellowish green, with brown patches at the base of the honey tubes.

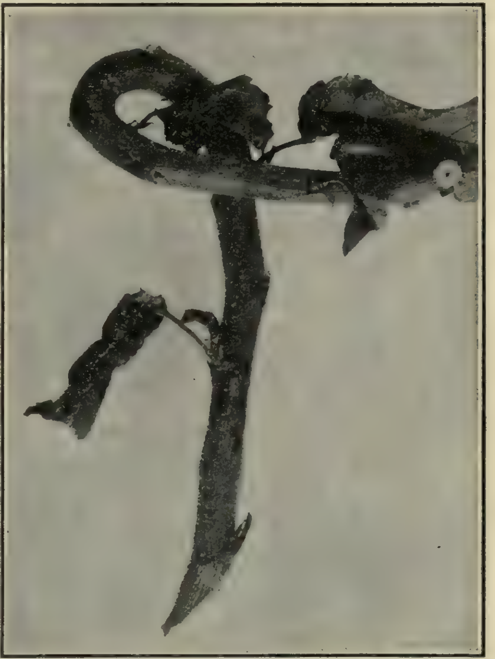

FIG. 4.—The rosy aphis: Twisted apple twig resulting from injury by this species. (Original.)

SEASONAL HISTORY.

The eggs of this species are deposited on the apple in the fall. They are light yellow when laid and change from green to polished black. They are placed upon the twigs, in the axils of the buds, or in crevices in the bark, but sometimes they are laid upon the larger branches. They begin hatching at about the time the buds are breaking in the spring.

The young stem-mother immediately begins feeding upon the bursting buds, and as the young leaves develop they curl about her. (Fig 5.) Usually in 15 days the stem-mother is mature, whereupon she begins producing young (fig. 2, *d*) at an average of 6 a day. The stem-mother lives from a month to six weeks.

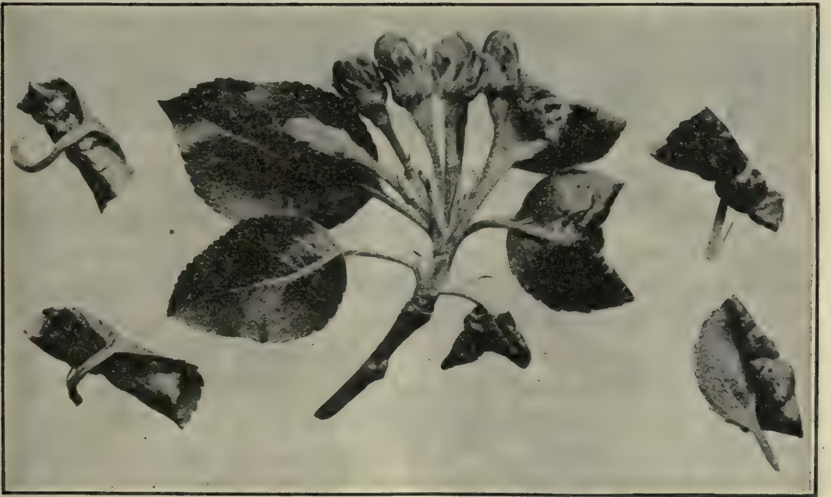

FIG. 5.—The rosy aphis: Condition of the foliage in spring when leaves curled by this insect are first in evidence. (Original.)

The offspring of the stem-mother may either become winged or remain wingless, and this condition may continue for at least 7 generations, so that during these generations both winged and wingless forms are to be found upon the apple. Occasional colonies of wingless forms (fig. 2, *a*) may be found throughout the summer upon the apple. The winged forms, however (fig. 2, *f*, last immature stage, or pupa; fig. 2, *e*, adult) when mature fly to plantains and settle upon the underside of the leaves, or upon the flower stems, where they produce young (fig. 2, *g*). They live principally upon the species known as rib grass, long-leafed plantain, or buckhorn plantain.[1] This migration to the plantains continues, in the vicinity of Washington, from the middle of May until the first part of July. On the plantains the insects continue to reproduce during the summer months. Most of the forms produced on these plants are wingless, although a few winged ones occur throughout the summer. The color of these forms is yellowish green, in contrast to the pink or rosy color of those upon the apple. From 4 to 14 generations of the summer forms occur upon plantain in the vicinity of Washington.

In the middle of September winged forms, consisting of fall migrants (agamic females) and males, begin to appear upon the plantains. These winged forms are able to live and reproduce only upon apple trees or closely related species. The fall migrants leave the plantains and settle upon the underside of the apple leaves, where they produce the young egg-laying females. These egg-laying females are wingless and pale yellowish. The males, which are similar in color to the fall migrants, often being nearly black, fly from the plantains and find the egg-laying females upon the trees. Here mating takes place and the females deposit their eggs about the middle of October. As later females are produced by later migrants, egg-laying continues until freezing weather has killed all the females.

THE GREEN APPLE APHIS.[2]

The green apple aphis lives on the apple throughout the year, and infests the tender terminal growth, causing the leaves to curl, as shown in figure 6, *a*, and figure 7. In young orchards by midsummer the shoots and leaves of the trees may be more or less generally infested, often so much so as decidedly to check the growth. Such trees are likely to be more or less sooty in appearance and overrun with ants. Water sprouts and the shoots of top-worked trees are especially liable to attack. This is the species commonly present on the shoots of apple nursery stock, and much complained of during some years. The work of this aphid is at times confused with that of the apple leafhopper,[3] which distorts the leaves in a manner more or less similar.

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[1] *Plantago lanceolata.*

[2] *Aphis pomi* DeGeer.

[3] *Empoasca mali* Le Baron.

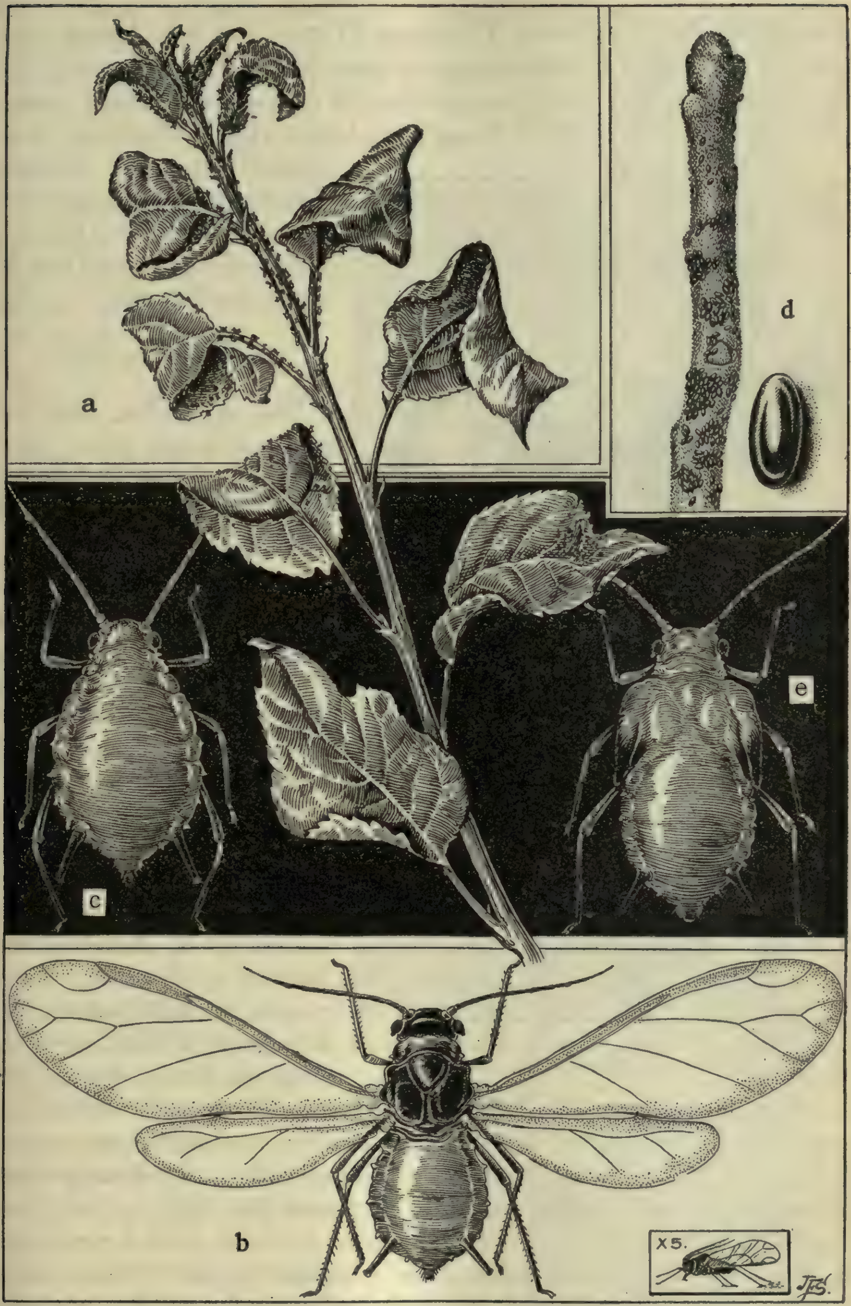

FIG. 6.—The green apple aphis (*Aphis pomi*): *a*, Injury to apple shoot; *b*, spring migrant; *c*, wingless agamic female; *d*, winter eggs on apple shoot; *e*, pupa of spring migrant. *b*, *c*, and *d* (at right), greatly enlarged. (Original.)

The green apple aphis is uniformly green, with black legs, feelers, and honey tubes. Occasionally forms are met which are yellowish, instead of a distinct green. The winged forms (fig. 6, *b*) have a black head and body and a uniformly green abdomen. The males and egg-laying females, which are met during the fall, are somewhat smaller and different in color from the agamic forms (fig. 6, *c*) which occur throughout the summer. The males are orange yellow, sometimes with a brownish tinge, and the females dark green.

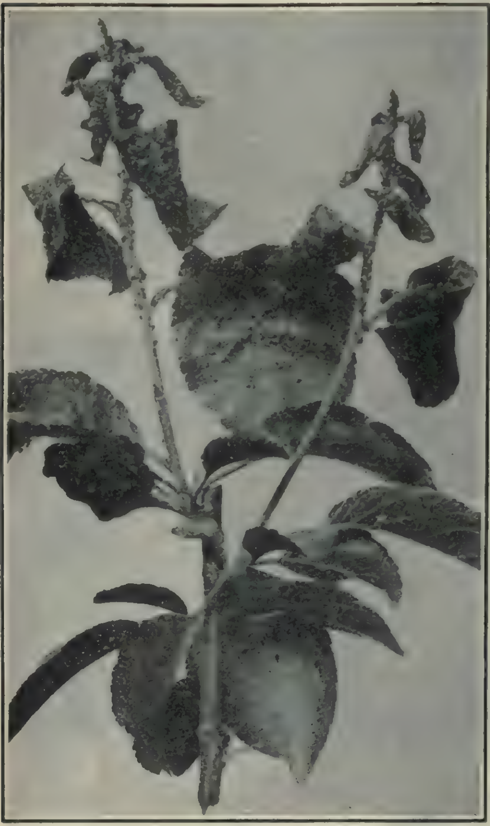

FIG. 7.—The green apple aphis: Curled condition of apple foliage due to this insect. (Original.)

SEASONAL HISTORY.

The eggs when first laid are yellowish green, later turning to polished black. They are laid in the fall upon the smooth twigs and water sprouts of the apple (fig. 6, *d*, fig. 8), and seem to be laid rarely on the trunks and larger limbs. A very small percentage of the eggs of this species, sometimes as low as 2 per cent, hatches. Hatching occurs at about the same date in the spring as in the case of the rosy aphis.

The young stem-mothers mature in about 10 days, and in about 24 hours after becoming adult begin to produce living young, reproduction continuing for about two weeks. Between 40 and 50 living young are produced by each stem-mother, at the average rate of 4 a day, although many more may be born daily. Of these young, some develop into winged forms, or migrants (fig. 6, *e*, *b*), and some remain wingless (fig. 6, *c*). They mature in a little over a week, and in turn produce either winged or wingless forms. Occasionally another form, intermediate between the winged and the wingless forms, is met. This reproduction continues throughout the summer, from 9 to 17 summer generations occurring before the sexual forms appear. The true sexes, therefore, appear from the tenth to the nineteenth generation, depending upon the rate of reproduction of their ancestors and upon the time of their birth—that is to say, whether they are early or late young of the parents.

The egg-laying females become adult in from 6 to 16 days, depending upon weather conditions. When adult they mate with the males and begin depositing their eggs upon the apple twigs. Females may be found on the trees until all the leaves have fallen, even when the weather is very cold.

THE OAT APHIS.[1]

The oat aphis, sometimes called the European grain aphis, is the earliest apple aphid to hatch in the spring; and as it often occurs in great abundance upon the buds and young foliage, it is frequently the cause of alarm on the part of orchardists. The species probably does not cause important injury, since it migrates from the apple shortly after the blossoms fall.

When first hatched the stem-mothers are very dark green, and they remain this color until after the first molt, when they become much paler. The adult wingless forms are pale green, with rusty areas around the base of the honey tubes, although in the summer some individuals become slightly purplish. The winged forms have black head and body with a green abdomen which is marked with black patches along the sides. The honey tubes, antennæ, and feet are black. The egg-laying females, which occur in the fall, have an olive cast.

SEASONAL HISTORY.

During warm days in winter many of the eggs of this species hatch on the

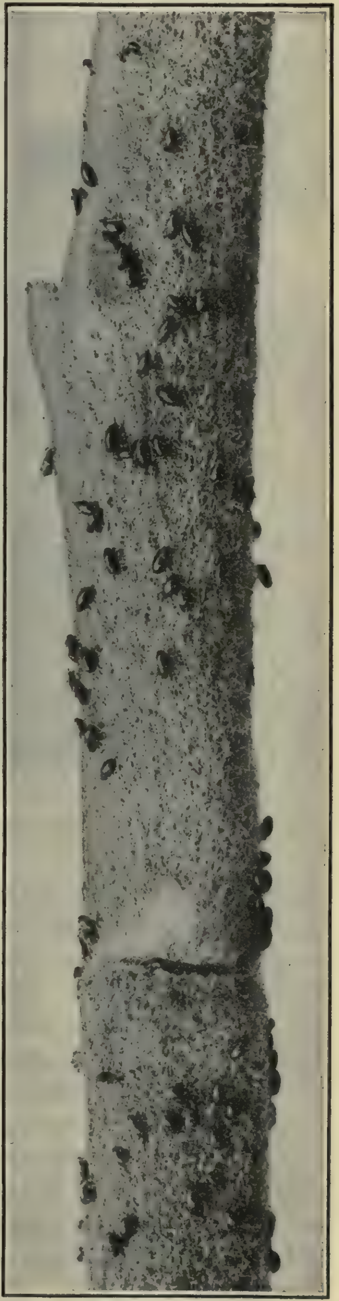

FIG. 8.—The green apple aphis: Winter eggs on apple twig. Much enlarged. (Original.)

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[1] *Aphis avenae* Fab.

trees, but it is not until about the middle of March, in the vicinity of Washington, that those hatching succeed in escaping destruction and produce stem-mothers. In fact, aphids from eggs hatched before April 1 are sometimes all killed by cold. The important hatching, therefore, commences after April 1.

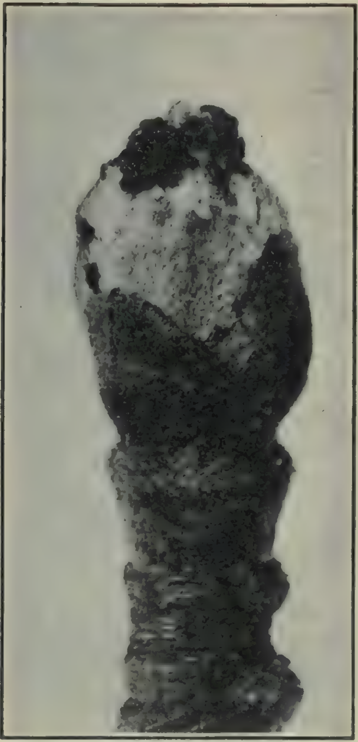

FIG. 9.—The oat aphis: Young stem-mothers clustered on opening apple bud. Much enlarged. (Original.)

The young stem-mothers of this species usually are abundant upon the swelling apple buds (fig. 9), and when these begin to open the insects crowd down among the bursting leaves. By the time the stem-mothers are adult—usually in about 13 days—many of the buds have opened and the leaves expanded. Each stem-mother produces about 100 young, and these migrate to the underside of the leaves, which become coated with them. These young may become either winged (fig. 11) or wingless adults (fig. 10), and at least four generations may be produced upon the apple. The wingless forms upon apple become mature in about seven days, and each individual produces about 75 young. The period of reproduction lasts a little over two weeks, and the insects live about a month.

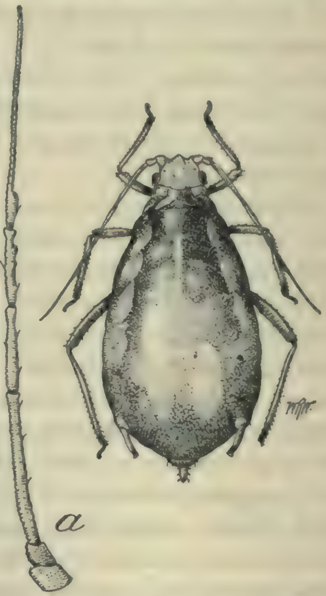

FIG. 10.—The oat aphis (*Aphis avenae*): Wingless agamic female, greatly enlarged. *a*, Antenna of same, still more enlarged. (Davis.)

The winged forms produced upon apples become mature in a little over 8 days and then fly to grains and grasses, as wheat, oats, etc.

In the autumn migrants are produced on grains. These mature in about 2 weeks and return to the apple, the migration lasting 3 or 4 weeks, since not all the migrants are produced in the same generation. During their life of some 6 weeks these migrants produce about 5 egg-laying females each.

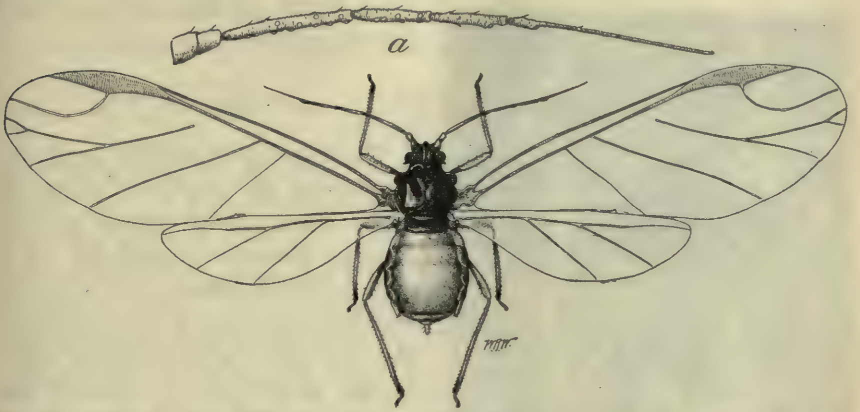

FIG. 11.—The oat aphis: Winged agamic female, greatly enlarged. *a*, Antenna of same, still more enlarged. (Davis.)

The winged males are produced upon the summer food plants and migrate to the apple leaves to mate with the sexual females. After the female has become fertilized she deposits her eggs in crevices of the bark of the larger branches or behind the bud scales of the young twigs of the apple. (Fig. 12.) The length of life of each sex depends upon weather conditions. This is particularly true of the female, which sometimes lives for weeks in a more or less dormant state during cold weather. In warm climates the species may hibernate as wingless females upon the summer hosts.

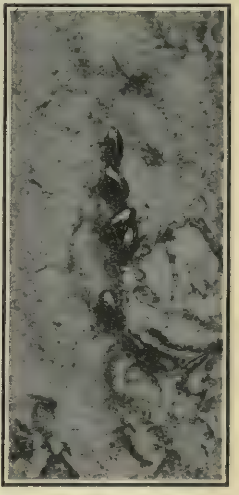

FIG. 12.—The oat aphis: Winter eggs on bark of apple tree. Much enlarged. (Original.)

THE CLOVER APHIS.[1]

The clover aphis, first found injurious to the apple in Colorado, is now known to occur abundantly in some regions in the East. It attacks the apple in a way similar to the green apple aphis, but since there is a considerable migration of individuals to clover, it is less abundant on the apple in summer than the latter species. The stem-mothers of the clover aphis are pink and the individuals of the next generation are yellowish green. The winged forms have a large black patch on the abdomen and in this way resemble the migrants of the rosy aphis. The two species, however, can be distinguished readily by the length of the honey tubes. In the rosy aphis these are very long, while in the clover aphis they are short. The forms of this species which live on clover are pink.

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[1] *Aphis bakeri* Cowan.

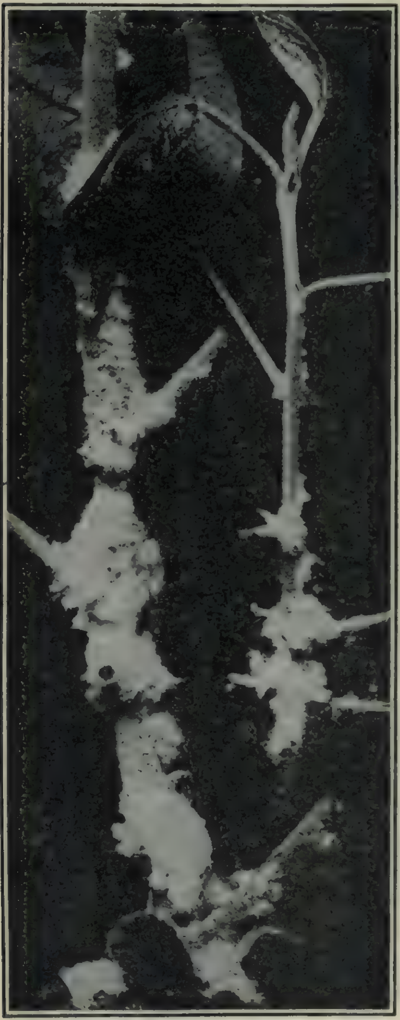

FIG. 13.—The woolly apple aphis (*Eriosoma lanigerum*): Colonies on apple shoots. (Original.)

SEASONAL HISTORY.

The eggs of the clover aphis are laid upon the apple in much the same manner as those of the species already mentioned. The stem-mothers, which are hatched considerably earlier than those of the rosy aphis and the green apple aphis, give birth to winged and wingless forms, which in turn produce young, some of which become winged, while the others remain wingless. As a rule most of the insects have become winged by early summer, although some wingless colonies occur during the summer on apple. These winged forms fly to clovers, and settling upon the stems produce wingless young. These and succeeding generations, which may contain winged individuals, pass down to the crown of the clover plants, and here the species lives throughout the summer. During October numerous fall migrants are produced upon the clovers and fly to the apple, where they give birth to the young egg-laying females. Winged males produced upon the clovers follow the fall migrants to the apple, and here mate with the females, which later deposit their eggs.

THE WOOLLY APPLE APHIS.[1]

The woolly apple aphis is often in evidence in summer on the trunk, branches, and twigs of the apple as bluish white cottony patches (fig. 13) which hide the rusty or purplish brown aphids beneath.

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[1] *Eriosoma lanigerum* (Hausm.)

While principally injurious to the roots of the apple, its injuries above ground are at times quite important. In orchards grown under arid or semiarid conditions in the West it is decidedly more troublesome than in the East, attacking the tree wherever the bark is tender and sometimes infesting the stems of the leaves and fruit. Its injuries above ground often result in galls or swellings similar to those on the roots, and when the fruit spurs are invaded (fig. 14) the fruiting capacity of the tree may be interfered with seriously. The usual contact sprays will be effective in destroying this pest on the limbs and branches. Its treatment on the roots of the apple requires essentially different methods, which are not considered in this bulletin.

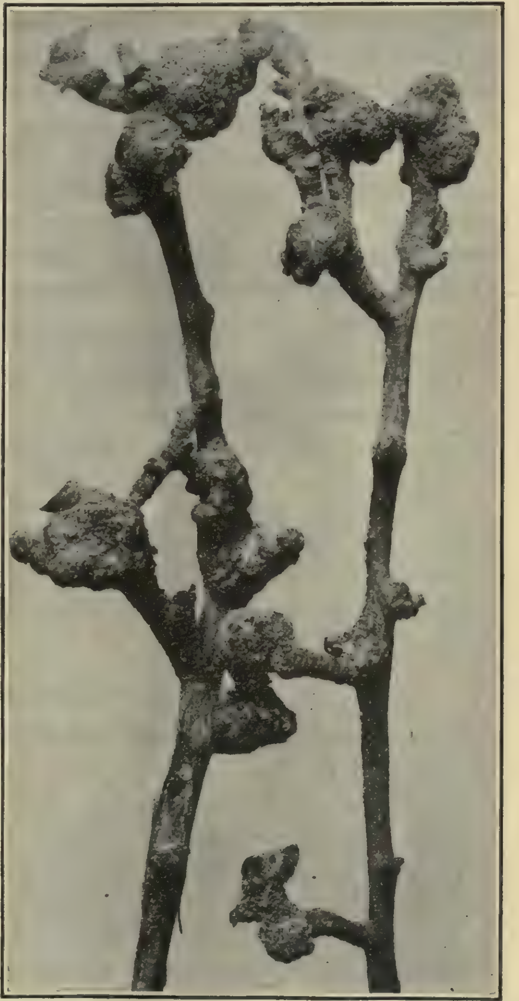

FIG. 14.—The woolly apple aphis: Injury to fruit spurs of apple. (Original.)

APPLE APHIDS OF MINOR IMPORTANCE.

Several additional species of aphids are found upon the apple, but these are at present of minor economic importance.

The potato aphis[1] has been found feeding upon apples occasionally in the spring. Its normal winter host appears to be the rose. This form is very much larger than the others mentioned, and the winged forms, as well as the wingless one, is uniformly light greenish.

Another species, which is slaty blue or black, with white bands upon the legs, and often possesses white waxy tufts, occurs sometimes upon the apple. This is the dock aphis.[2] The apple does not seem to furnish suitable food to these insects, for after a few generations they always leave the trees.

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[1] *Macrosiphum solanifoliae* (Ashm.).

[2] *Aphis rumicis* L.

A second dark brown or blackish species which occurs occasionally upon apples is the bur-clover aphis.[1] It is sometimes met during the spring upon apple foliage.

Still another species, the wild-carrot aphis,[2] occurs commonly on the apple in the fall, particularly as the winged form. Its summer hosts are the wild carrot and related plants, and the winged forms fly to honeysuckles, but occasionally select apples.

The thorn-leaf aphis[3] also is found occasionally upon apple. Its life history is discussed under aphids attacking the quince.

QUINCE APHIDS.

Two species of aphids which have been discussed under apple occur commonly also upon quince foliage—namely, the green apple aphis and the oat aphis. Their life histories are similar on quince and apple, and the same remedial measures apply.

THE THORN-LEAF APHIS.

The thorn-leaf aphis,[3] called also the long-beaked clover aphis, is most common upon hawthorn trees. Although first found upon thorn, it is not uncommon upon quince leaves. It resembles very closely the clover aphis as found upon apple, but can be distinguished from that insect by its long beak.

On thorn trees the feeding of this species results in a curling of the leaves which is very conspicuous, the twisted leaves taking on a purplish cast. On quinces, however, it does not curl the leaves, or at least not to such an extent.

SEASONAL HISTORY.

The eggs of this insect are laid in the fall upon the twigs of the quince, and the stem-mothers hatch in the early spring. By early summer the insects are abundant and winged forms are being produced. This production of winged forms, or migrants, continues until late summer. The migrants fly from their winter hosts to clovers and peas and produce numerous generations on these plants in a manner very similar to that of the clover aphis. In the fall, migrants are produced which return to the quinces and produce the egg-laying females, which after mating with the males deposit the winter eggs. The flight of the insects from clover begins in September and extends throughout October.

PEAR APHIDS ATTACKING THE FOLIAGE.

Several species of aphids are found upon pear foliage. Most of these, however, occur also upon other trees and are treated elsewhere in this bulletin. The more common forms upon pear are the green apple aphis, the oat aphis, and the clover aphis.

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[1] *Aphis medicaginis* Koch.

[2] *Hyadaphis xylostei* (Schrank).

[3] *Aphis crataegifoliae* Fitch.

Another species, the woolly thorn aphis[1] is common in some localities. Both winged and wingless forms are covered with a white waxy substance. The wingless forms are pale green and the winged forms have a black head and body. The insects hatch in the early spring and soon attack the leaves, curling and twisting them. During early summer the winged forms leave the pear tree. In the fall migrants may be found again, and these produce the sexual forms, the females of which lay their eggs upon the bark. Besides pear, this species occurs upon thorn, quince, and Juneberry.

Two other forms are found commonly upon pear, but these occur upon the roots, and since they are seldom found upon the branches and foliage and require different remedial measures, they are not treated in this bulletin. The first of these is the woolly pear aphis,[2] which is common in the western part of the country, and the second is Fitch's pear root aphis,[3] which is very similar to the woolly thorn aphis and occurs in the eastern United States.

PLUM APHIDS.

Three or four species of aphids are common on the plum, two of which are, during some seasons, very injurious. Many complaints of injury to Japanese and native plums by the rusty plum aphis have come from the more southern States, while the mealy plum aphis is more often prevalent in the North and West, on Domestica, or the European type of plums. The hop aphis, according to records of the Bureau of Entomology, has not occasioned much injury to plums in recent years, although in the Pacific Northwest it continues to be a pest of importance to hops.

THE RUSTY PLUM APHIS.[4]

The rusty plum aphis was discovered and named from individuals feeding on grass, but is better known by its injuries to plums. It is rusty brown or deep purplish, with white bands upon the legs.

This species feeds upon the tender twigs and foliage of the plum and also upon the peach. The first stem-mothers attack the buds just as they are expanding in the spring and later crawl down among the opening leaves. As the season advances whole twigs or small branches may be literally crowded with the aphids (fig. 15), and such twigs usually die. Another species, not yet named, also has this habit, and this form may be very injurious to the twigs, as it remains on the plum throughout the summer.

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[1] *Prociphilus corrugatans* (Sirrine).

[2] *Eriosoma pyricola* B. & D.

[3] *Prociphilus pyri* (Fitch).

[4] *Aphis setariae* Thos.

SEASONAL HISTORY.

The eggs of the rusty plum aphis hatch early in the spring and the normal life period of the stem-mother is about a month. During this time she produces young at the rate of four to six a day. In a little over a week these young are mature and reproducing, so that large colonies soon result. A few winged forms occur in the early generations, but it is not until late spring that a large percentage of spring migrants is found. These winged forms fly from the plum and settle upon various grasses, where they produce colonies throughout the summer around the crowns of the plants. In October the fall migrants are produced upon the grasses, return to the plum, and there give birth to the egg-laying wingless females. The males, also produced upon the grasses, migrate to the plum in order to locate and fertilize the egg-laying females. In some regions the species seemingly lives on the plum throughout the year.

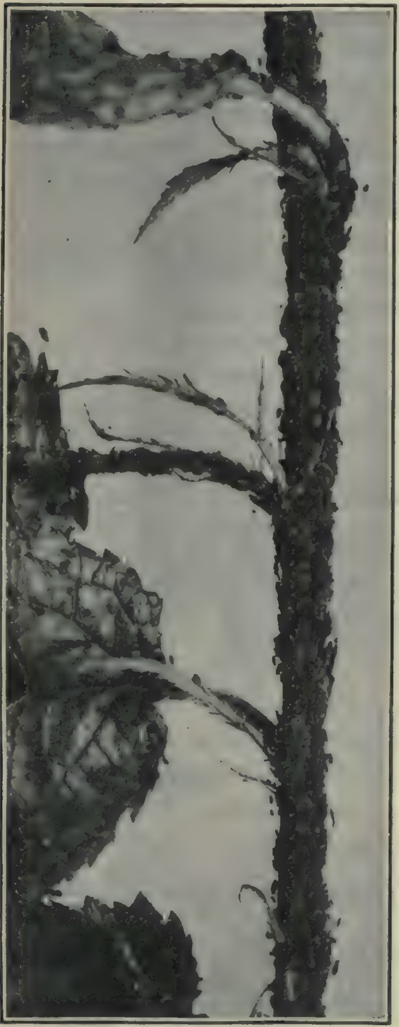

FIG. 15.—The rusty plum aphis (*Aphis setariae*): Colony on shoot and foliage of plum. (Original.)

THE LONG-BEAKED THISTLE APHIS.[1]

In some localities the long-beaked thistle aphis is abundant on plum trees. In structure this species most closely resembles the rusty plum aphis. The insects are shiny green and black, some of the wingless ones and all of the winged ones having a large black patch on the abdomen.

Although this species becomes very abundant on the trees, it does not curl the leaves to any extent. Trees have been observed in the vicinity of Washington with the underside of nearly every leaf thickly covered with the insects, and yet these leaves were rolled only slightly from the edges. The insects always feed on the underside of the leaves or on the very tender twigs. Practically all the injury done to the trees is by the spring forms, the fall migrants being scattered.

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[1] *Aphis cardui* L.

SEASONAL HISTORY.

The eggs of this species are laid upon the plum, as are those of the rusty plum aphis. In the early spring the stem-mother hatches and gives birth to living young. Winged forms begin to appear as early as the second generation and continue to be produced until midsummer. These migrate to thistles, where they produce the first of the summer forms. After having produced numerous generations on the thistle during the summer, fall migrants are produced which return to the plum trees to deposit the young egg-laying females. These, after being fertilized by the males, lay the winter eggs.

THE WATER-LILY APHIS.[1]

Plum trees are sometimes thickly infested by an aphid with swollen honey tubes, the water-lily aphis. The insects are brownish, the winged forms having a black head and body.

The spring forms feed upon the underside of the leaves or on the tender twigs of the plums, but they do not curl the leaves to any extent. The summer feeding habits of the species on water plants are very interesting, as colonies often are partially submerged for some time without apparent injury.

SEASONAL HISTORY.

The stem-mothers of this species hatch early in the spring upon the plum, and soon the young produced cover the lower side of the leaves and the twigs. Winged forms are found during June and these fly to various water plants, on which they reproduce and live during the summer months. In the fall the migrants return to the plum and produce the egg-laying females, which, when adult, are fertilized by the winged males. The flight of the fall migrants and males extends over a long period, the males having been found on the plum trees from early until late fall.

THE HOP APHIS.[2]

A large green aphid, the hop aphis, is in some regions very common upon plums in the spring. The wingless forms are light green and the winged forms are light green with black head and body and a patch of the same color on the abdomen.

The stem-mothers of this species feed upon both the flower buds and the leaf buds of the plum. After the leaves have expanded the insects attack the underside of the leaves and often may be found thickly crowded thereon.

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[1] *Siphocoryne nymphaeae* (L.).

[2] *Phorodon humuli* (Schrank).

SEASONAL HISTORY.

The eggs hatch on the plum twigs considerably later as a rule than those of the thistle aphis. The young stem-mothers soon develop and begin the production of young. Winged forms soon appear, the greater number of these occurring in the third generation. These winged forms fly to hop vines, where they produce young that feed upon the hop plant. Eight or more generations of these summer forms are produced upon the hop, and winged fall migrants are then produced, which return to the plum trees to produce the sexual females. Males appear during the fall for a period of several weeks, the last ones usually occurring late in October or in November. These fertilize the egg-laying females, which then lay their eggs upon the twigs.

In some cases the species is able to complete its life cycle on the hop and does not necessarily alternate with the plum, whereas in other cases it remains all summer upon the plums.

THE MEALY PLUM APHIS.[1]

The mealy plum aphis is a common form on plum trees and it can be distinguished from the other species attacking plum foliage by its uniform green color and the fine, white, powdery covering of the body. The honey tubes also differ in that they are very short.

These insects feed upon the underside of the leaves, often being very closely packed together. (Fig. 16.) As a rule they do not curl the leaves, even when present in great numbers.

SEASONAL HISTORY.

The stem-mothers of this species hatch from the winter eggs on the plum early in the spring and in about 10 days they are mature. They then give birth to young, and these when grown produce others until the leaves are often thickly covered with the insects. Winged forms develop toward late spring and continue to appear until late midsummer or later. These winged forms migrate to certain grasses and produce numerous generations during the summer. In the fall return migrants are produced, which give birth to the egg-laying forms on the plums. These migrants first appear in early September, but continue to arrive until late October or early November.

CHERRY APHIDS.

THE BLACK CHERRY APHIS.[2]

The black cherry aphis is an abundant species almost everywhere upon cherry trees. The wingless insects have a rounded abdomen, which gives them a more or less globular appearance. Both wingless and winged forms are shining deep brown to black, while the color of the young ranges from amber through various shades of brown. The young stem-mothers are deep greenish.

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[1] *Hyalopterus arundinis* (Fab.).

[2] *Myzus cerasi* (Fab.).

On account of their early hatching in spring the young stem-mothers do not find leaf food available. They therefore attack the buds even before these show any signs of bursting. Sometimes the stem-mothers will feed in this manner for nearly a week before the buds begin to open. As soon as the leaves are formed the young insects attack them and cause them to curl. As they spread from leaf to leaf a large and conspicuous cluster of curled-up leaves (fig 17) is formed, within which the insects feed.

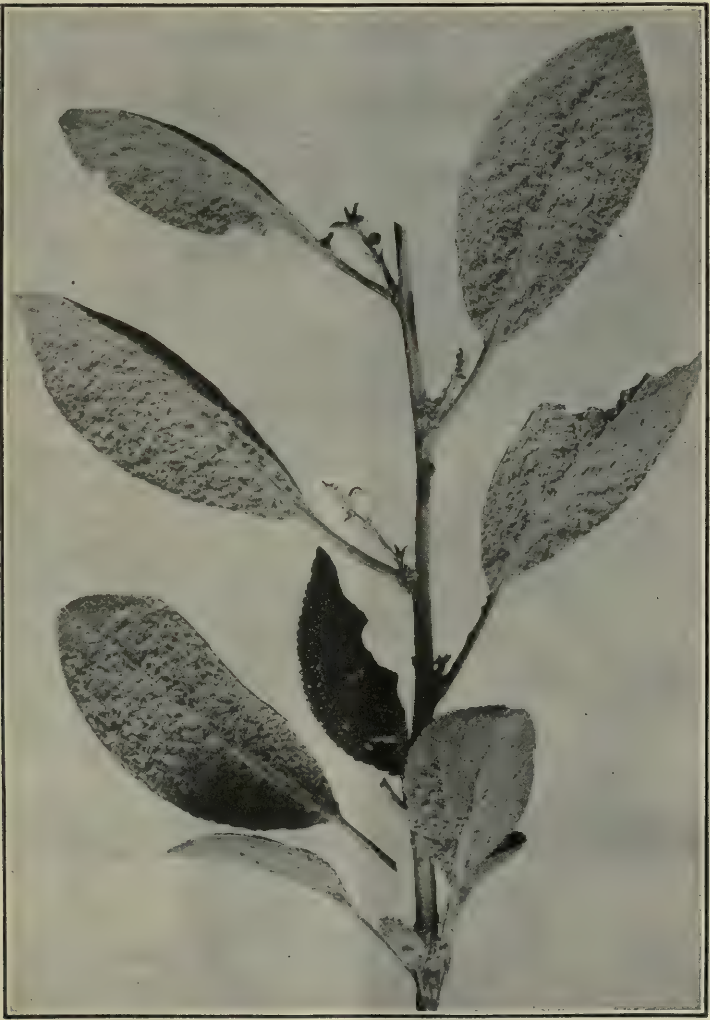

FIG. 16.—The mealy plum aphis (*Hyalopterus arundinis*) : Infested plum foliage. (Original.)

SEASONAL HISTORY.

The eggs are laid upon the cherry twigs in the fall and hatch early in the spring. The insects are able to withstand freezing weather, and after the return of warmer weather continue their activities. Within two or three weeks after hatching the stem-mothers are mature and produce young. These later generations become adult usually in less than a week. Some of the insects so produced become winged while others remain wingless. The winged ones migrate to some plant not known, and here the species lives throughout the summer. The wingless ones continue reproduction, and sometimes give rise to as many as 11 generations before the end of July. The numbers on cherry, however, gradually diminish, and during midsummer very few are seen upon the trees, and in some cases no insects can be found upon trees which earlier in the season were badly infested. During October fall migrants and winged males may be found returning to cherry trees and are often encountered during the migration period in larger numbers than might be expected. The fall migrants produce the egg-laying females which, when mature, are fertilized by the males.

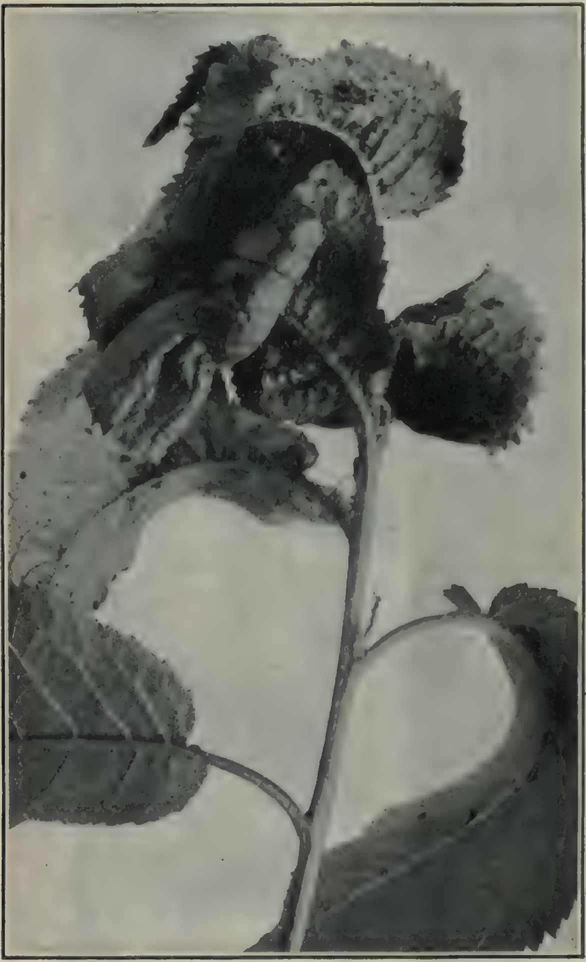

FIG. 17.—The black cherry aphis (*Myzus cerasi*): Curled terminal cherry leaves following attack by this species. (Original.)

THE CHOKECHERRY APHIS.[1]

The chokecherry aphis is found abundantly upon chokecherries and related trees. It is a pale green insect and is conspicuously mealy. The winged forms have a black head and body.

The feeding habits of this species are very similar to those of the black cherry aphis. The leaves of the terminal twigs are attacked and twisted by the feeding of the insects, entire twigs sometimes being destroyed.

As in the case of the black cherry aphis, the eggs of this insect are laid on the cherry twigs. After the stem-mothers have become mature and produced young, these latter crowd the terminal leaves. Winged forms are produced during early summer, and by midsummer the insects usually have disappeared from the trees. Their summer host is not known, but in the fall migrants return to the cherry trees to deposit the egg-laying females.

PEACH APHIDS.

THE GREEN PEACH APHIS.[2]

The green peach aphis is a common form upon peach trees. The stem-mothers in spring, as well as the fall egg-laying females, are often pinkish, and at other times light green. The wingless agamic form also is light green, while the winged individuals have a black head and body and a large dark-brown patch on the abdomen. This marking occurs upon both the spring migrant and the fall migrant. They are similar in other respects excepting that the fall form has the honey tubes somewhat swollen.

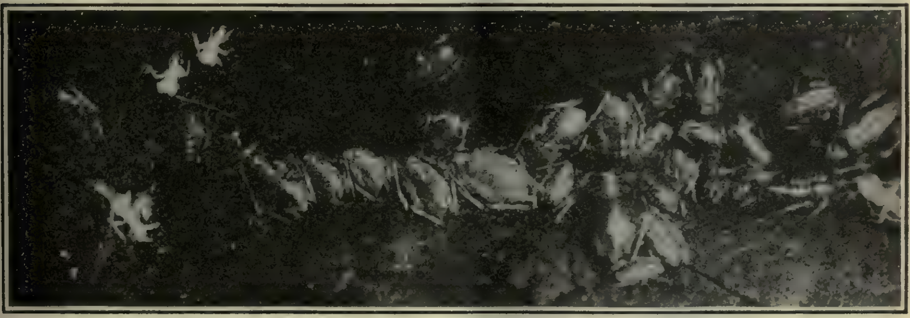

FIG. 18.—The green peach aphis (*Rhopalosiphum persicae*): Colony on underside of peach leaves. Much enlarged. (Original.)

On the peach this species feeds entirely upon the leaves, on which the insects may be found in large numbers crowded on the underside. (Fig. 18.) It has a large number of other food plants, including numerous garden vegetables.

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[1] *Aphis cerasifoliae* Fitch.

[2] *Rhopalosiphum persicae* (Sulz.).

SEASONAL HISTORY.

The eggs of this aphid are laid upon the peach twigs, and early in the spring before the buds are opened the green stem-mothers are hatched. From this form during the spring may be produced one or more generations of wingless individuals upon the leaves. Spring migrants, however, begin to occur very early and continue to appear until the middle of June. These fly to a large number of different plants, where numerous generations occur throughout the summer. During September and October fall migrants are developed which return to the peach, where they deposit the young egg-laying females. These are fertilized by the winged males, which also have returned to the peach, and the females then lay their eggs upon the twigs. Occasionally, however, migrants are found which do not return to the peach and these deposit egg-laying females upon the summer host plants.

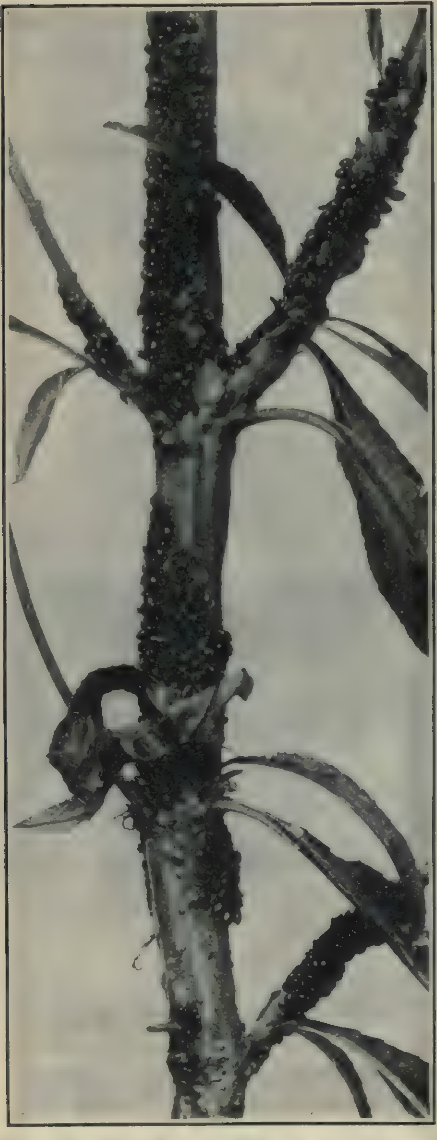

FIG. 19.—The black peach aphis (*Aphis persicae-niger*): Colonies on peach shoot in early spring. (Original.)

THE BLACK PEACH APHIS.[1]

The well-known black peach aphis is injurious to the twigs, shoots, and roots. It is shiny dark brown to black, with the young an amber color.

The insect lives throughout the year on the roots of the peach and is most injurious to peach growing on sandy soils. It is prevalent in portions of Maryland and in Delaware, New Jersey, and Michigan. Individuals migrate from the roots during the warm periods in winter or in early spring and start colonies on the twigs and young shoots. (Fig. 19.) Often these become so numerous as to cause the death of dormant-budded nursery trees (fig. 20) and do serious or fatal injury to young orchard trees. In mild climates the insects may exist all winter on the twigs, reproducing during periods of warmth, though the twigs are for the most part reinfested each year from the insects below the soil.

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[1] *Aphis persicae-niger* Smith.

The complaints of serious injury by this species on the roots of orchard peach trees, in the experience of the writers, have not been justified, the unthrifty condition of the trees being in most cases due to other causes.

SEASONAL HISTORY.

The complete seasonal history of this species is not known. The number of young produced by a given parent varies greatly, depending upon weather conditions. Sometimes only one young aphis a day will be produced, with a total of 25 or 30 young to a mother, while under favorable conditions as many as 12 young may be produced in a day and considerably over 100 as the total for a given parent. In spring large numbers of winged forms appear and the percentage of these gradually increases until all of the forms above ground have become winged. These fly to some plant or plants not known and are not met on peach foliage until the next year.

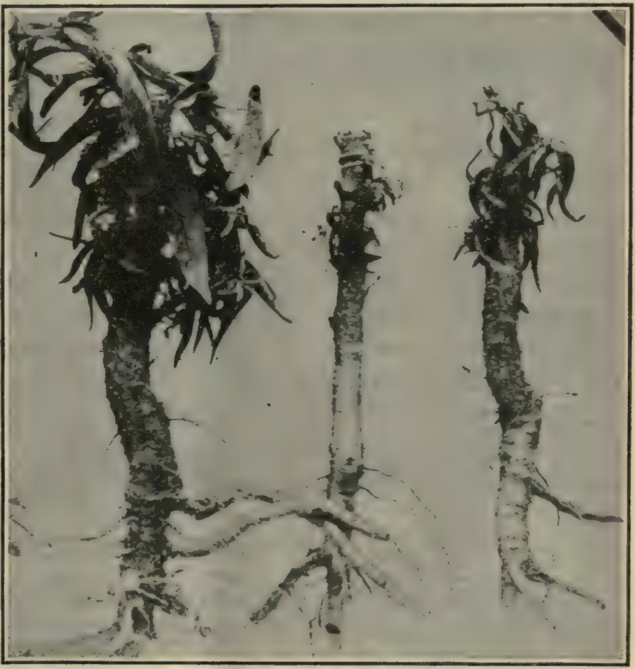

FIG. 20.—The black peach aphis: Injury to dormant-budded peach nursery stock in the spring. (Original.)

CURRANT AND GOOSEBERRY APHIDS.

THE CURRANT APHIS.[1]

The currant aphis is distributed over the entire country and its injury, on account of its conspicuousness, is the occasion of much complaint. The insect causes the terminal leaves to become much distorted, and little pits or pockets are formed on the underside. (See fig. 21, *b;* fig. 22.) The upper surface of the leaves assumes a more or less reddish color, evident some distance away. When the plants are badly infested these leaves fall and the fruit becomes poor and ripens prematurely. Red currants are most subject to attack, but black currants and gooseberries also are injured.

---

[1] *Myzus ribis* (L.).

The stem-mothers of the species are green, the other wingless forms (fig. 21, *a*) a yellowish green, while the winged ones have a black head and body and a large black patch on the abdomen. The eggs are polished black.

SEASONAL HISTORY.

The stem-mothers hatch from the eggs in the early spring soon after the leaves open. After completing their growth they produce young aphids which infest the lower surface of the leaves. Some of the offspring of the stem-mother are winged and these fly to some unknown host. The wingless ones remain upon the currants and continue reproduction. In each generation some winged forms occur, but wingless individuals are present until late in July upon the currants. In fact, occasional colonies remain throughout the summer. In the fall, during early October, migrants return to the currant bushes and deposit the sexual females. These when mature are fertilized by the winged males and the eggs are laid upon the twigs.

THE SOW-THISTLE APHIS.[1]

The sow-thistle aphis is at times quite as abundant on currants as is the currant aphis. It is somewhat similar in color but can be distinguished at once from the currant aphis by the swollen honey tubes. (Fig. 21, *c*.) In the currant aphis these are long and very slender. (Fig. 21, *a*.) The eggs are polished black. The sow-thistle aphis injures the currant in about the same way as does the currant aphis, though the infested leaves (fig. 21, *d*) do not take on a reddish coloration.

SEASONAL HISTORY.

The seasonal history of this species upon currants is very similar to that of the currant aphis. The winged forms, however, migrate to the sow thistle and upon this they reproduce. After the production of numerous generations here during the summer, fall migrants are developed which return to the currants. Egg-laying females are then produced and these are fertilized by the winged males. The eggs are laid upon the twigs at about the same time as those of the currant aphis.

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[1] *Rhopalosiphum lactucae* (Kalt.).

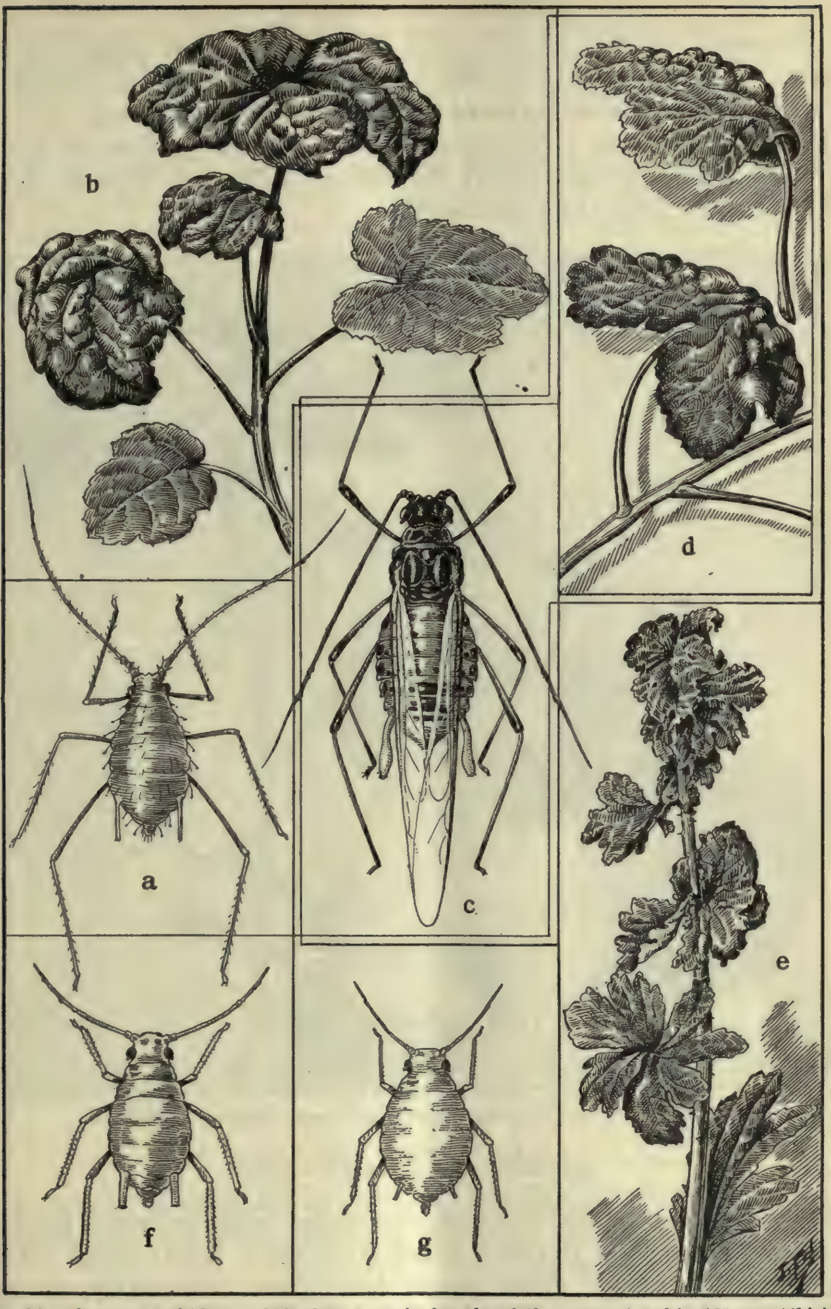

FIG. 21.—Currant aphids: *a,* Wingless agamic female of the currant aphis (*Myzus ribis*); *b,* distorted currant foliage due to attack of this species; *c,* spring migrant of the sow-thistle aphis (*Rhopalosiphum lactucae*); *d,* injury to currant by this species; *e,* work of the green gooseberry aphis (*Aphis sanborni*) on gooseberry; *f,* wingless agamic female of the New Mexico gooseberry aphis (*Aphis neomexicanus*); *g,* wingless agamic female of Sanborn's currant aphis (*Aphis ribis*). *a, c, f, g,* Greatly enlarged. (Original.)

THE GREEN CURRANT APHIS.[1]

A species which may be called the green currant aphis has for years been confused with the currant aphis, which it resembles closely. The wingless forms of the present species are green, whereas those of the currant aphis are yellowish. The life history, so far as is known, is very like that of the currant aphis and the two forms often may be found on the same leaf.

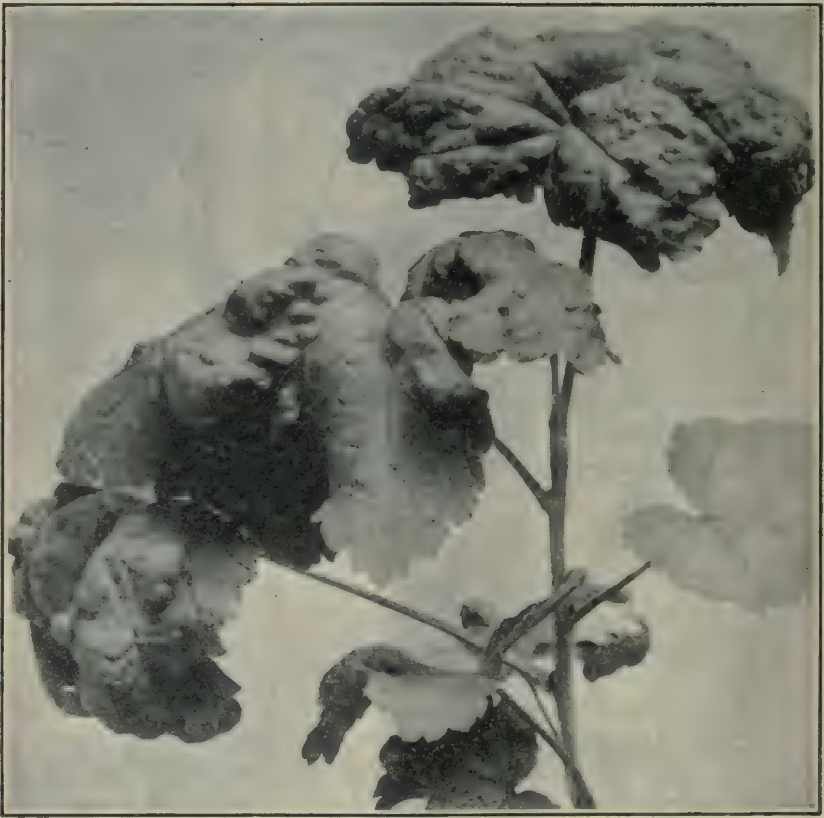

FIG. 22.—The currant aphis: Injury to currant foliage. (Original.)

THE VARIABLE CURRANT APHIS.[2]

The variable currant aphis is one of the most injurious species. The stem-mother is purplish green with white honey tubes. The wingless form is dark green, tan, or dark brown, whereas the winged form has a black head and body, with a dark green abdomen marked near the tip and on the sides with black.

As soon as the stem-mother begins to feed, the young leaf begins curling about her. As young are produced other leaves are attacked until large irregular bunches of twisted leaves occur. Later the insects attack the shoots, sometimes thickly covering them. The species infests currants, gooseberries, and flowering currants.

---

[1] *Myzus dispar* Patch.

[2] *Aphis varians* Patch.

SEASONAL HISTORY.

The stem-mother hatches from the eggs early in the spring and becomes mature early in May. She produces young which are all wingless. These in turn produce young which may or may not be winged. The winged ones take flight to some unknown summer host, while the wingless ones continue the infestation upon the currants until nearly midsummer. In the fall migrants return to the currants and produce young which develop into males and egg-laying females, the latter depositing eggs upon the twigs.

THE GREEN GOOSEBERRY APHIS.[1]

The green gooseberry aphis is a green species with white honey tubes. It lives upon the underside of gooseberry leaves, which it deforms badly (fig. 21, *e*), and also upon the twigs.

The seasonal history of this species has not been determined. The winter eggs are laid upon the host plant upon which the stem-mother develops. Wingless forms occur later than the stem-mother, and winged ones also are produced upon the gooseberry.

THE HOUGHTON GOOSEBERRY APHIS.[2]

A pale green species is sometimes found curling the leaves of Houghton gooseberries. The winged forms are somewhat darker than the wingless ones. The life history of the species is unknown.

THE NEW MEXICO GOOSEBERRY APHIS.[3]

Another species is found on gooseberries in New Mexico. The wingless forms (fig. 21, *f*) are green, while the winged forms have black head and body, with green abdomen marked with some dark bands or spots. Its life history is unknown. A variety of this species is found in California, feeding upon the red currant.

SANBORN'S CURRANT APHIS.[4]

A small species of aphid occurs in the Middle West and Southwest on Missouri gooseberries and cultivated currants. This is Sanborn's currant aphis. The wingless forms (fig. 21, *g*) are green, and the winged forms have black head, body, legs, honey tubes, and antennæ. The species is found in the spring in rather large colonies on the underside of the leaves, which it causes to curl and twist.

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[1] *Aphis sanborni* Patch.

[2] *Aphis houghtonensis* Troop.

[3] *Aphis neomexicanus* (Ckll.).

[4] *Aphis ribis* Sanborn.

GRAPE APHIDS ATTACKING THE FOLIAGE.

The well-known grape phylloxera occurs in some localities upon grape foliage (fig. 23), but this species is not treated in this bulletin, since it is injurious principally to the roots and requires control measures radically different from those employed against foliage-inhabiting species.

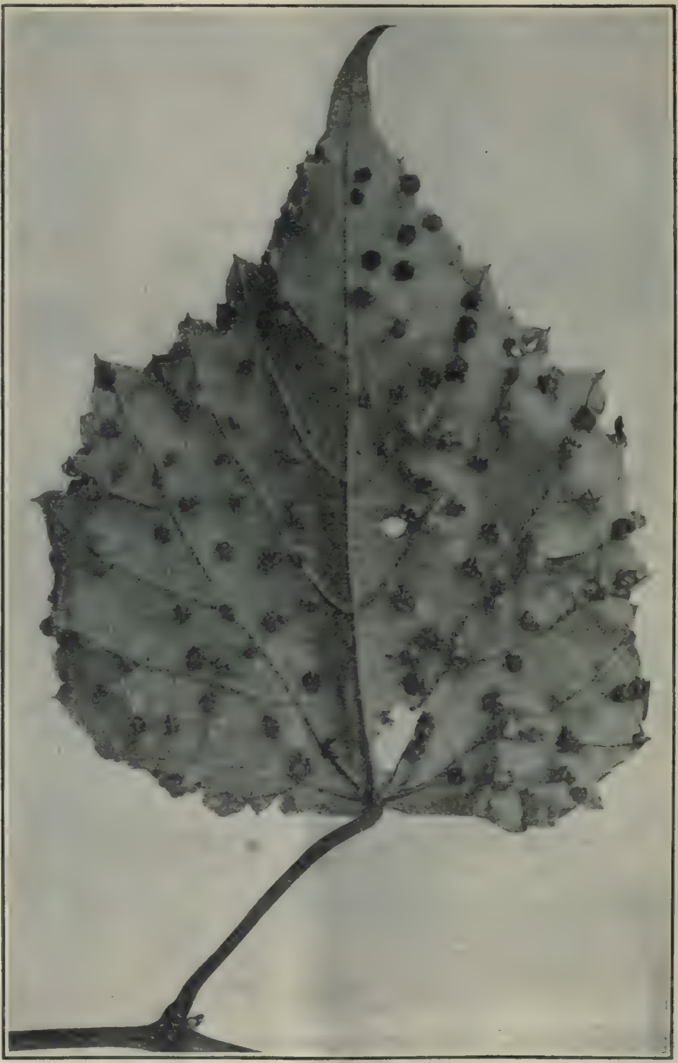

FIG. 23.—Galls of grape phylloxera (*Phylloxera vitifoliae*) on grape leaf. (Original.)

THE GRAPEVINE APHIS.[1]

The grapevine aphis is very numerous in some localities, infesting the tender shoots and leaves (fig. 24) and sometimes the fruit clusters, causing the berries to drop. It can be distinguished easily from any other forms occurring upon grape by its large size and its dark-brown color.

SEASONAL HISTORY.

The eggs of this species are laid upon the twigs of the black haw (*Viburnum prunifolium*). Very early in the spring they begin hatching, but these first stem-mothers may be killed by frost. Six or eight weeks later the aphids of the second generation mature, and these nearly all become winged. These migrants fly to the grape and produce young upon the tender growing shoots, where in less than 10 days they are mature and producing young. Reproduction on the grape continues throughout the summer, and often more than a dozen generations may occur. In each generation winged forms are found, and these carry the infestation to new vines. During October fall migrants are produced, which return to the haw trees and deposit the egg-laying females. When mature these are fertilized by the winged males which follow the fall migrants, and egg laying follows.

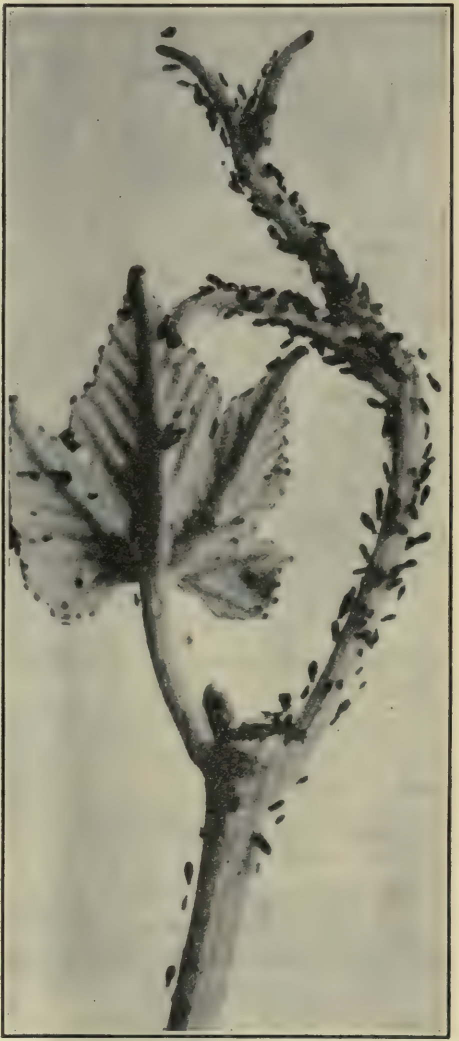

FIG. 24.—The grapevine aphis (*Macrosiphum illinoiensis*): Colony on grape shoot. (Original.)

NATURAL ENEMIES OF APHIDS.

Aphids are attacked by various species of parasitic and predacious insects and by fungous diseases, and these agencies exert a very important influence in their control. The combined effect of these several factors normally keeps the aphids pretty well reduced, but when for any reason their activities are lessened the aphids may increase enormously and do widespread injury. Heavy driving rains are believed to be inimical to aphids, whereas cool, cloudy weather seems to reduce the activities of the parasitic and predacious enemies, permitting the aphids to become correspondingly abundant.

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[1] *Macrosiphum illinoiensis* (Shimer).

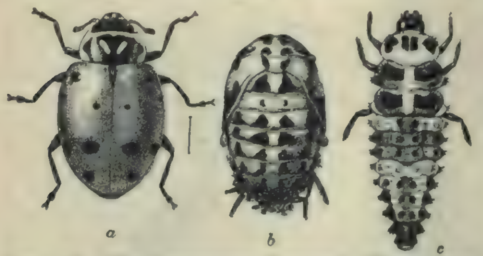

FIG. 25.—The convergent ladybird (*Hippodamia convergens*), an enemy of orchard aphids: *a*, Adult; *b*, pupa; *c*, larva. Enlarged. (Chittenden.)

Ladybird beetles (fig. 25) may be found in almost any colony of aphids, both the beetles and larvæ feeding freely on the insects. Numerous species of these beetles attack the aphids, and they should be protected and encouraged when possible.

Larvæ, or maggots, of syrphus flies, also called sweat flies (figs. 26 and 27), are very generally present in aphid colonies and are most important checks to their increase.

The larvæ of two or three species of lacewing flies feed freely on aphids, although they are not so important as the insects mentioned above.

Probably the most important check to aphid increase, however, is the work of certain minute, four-winged flies which live parasitically on the aphids. These multiply very rapidly and under normal conditions are very effective. The bodies of parasitized aphids usually become enlarged, assume a more or less globular shape, and finally show the exit hole of the adult parasite. (Fig. 28.)

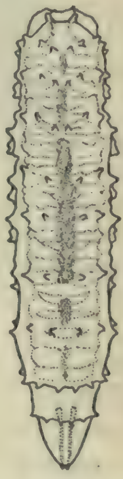

FIG. 26.—Larva of the syrphid fly *Allograpta obliqua*, an important enemy of aphids. Much enlarged. (Metcalf.)

CONTROL MEASURES.

As previously stated, aphids feed upon plant juices which they obtain by means of a beak inserted into the plant tissues. Paris green, arsenate of lead, and other arsenicals, or stomach poisons, are therefore ineffective against these insects, and the so-called contact sprays, such as kerosene emulsion, soap washes, nicotine sprays, etc., must be employed. These sprays, to be effective, must come in contact with the bodies of the insects, and great thoroughness in spraying is necessary.

Two principal plans of attack may be followed in the control of orchard aphids. Those species which winter in the egg stage on the plants to be protected may be treated with sprays early in the spring as the buds are expanding, to destroy the young stem-mothers. Treatment at this time assumes that without it the aphids would become injurious later in the season and is in the nature of insurance.

Following the other plan, spraying is not done until the insects actually have become troublesome, which does not occur as a rule until several weeks after the foliage has put out. With species that cause the leaves to curl this is too late to obtain much benefit from spraying. In view of the more or less scattered occurrence of aphids many growers will prefer to delay treatment until the insects actually are present on the plants in destructive numbers, and in the case of those species which do not curl the leaves to any extent this plan will be satisfactory. It is a question for the grower to decide whether under his conditions danger of aphid injury, especially by the leaf-curling species, makes the bud application desirable or whether this danger is so small that he is warranted in taking chances on the insects becoming troublesome. Examinations of the plants to determine the abundance of winter eggs and young stem-mothers on the opening buds should be of assistance in this connection.

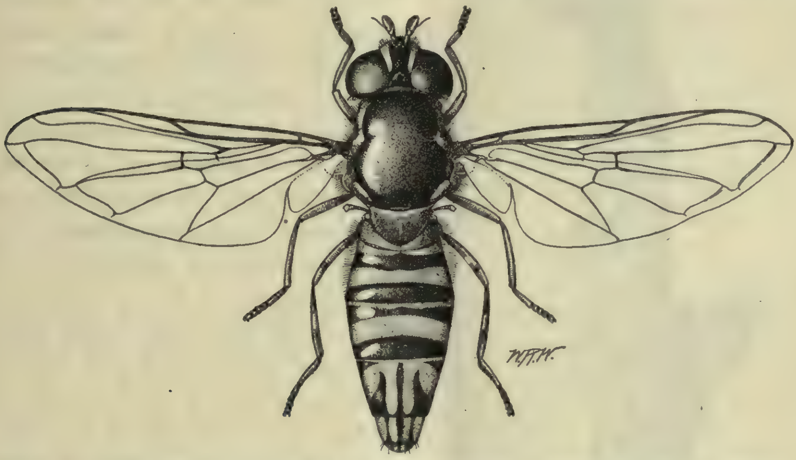

FIG. 27.—The adult syrphid fly *Allograpta obliqua*. Much enlarged. (Davis.)

SPRAY FORMULAS.

COMMERCIAL NICOTINE SOLUTIONS.

Aphids are killed by surprisingly small quantities of nicotine in water, and because of the entire safety with which it may be applied to plants nicotine is better suited than other sprays to control these insects. While the cost of the concentrated article is high, the ex-

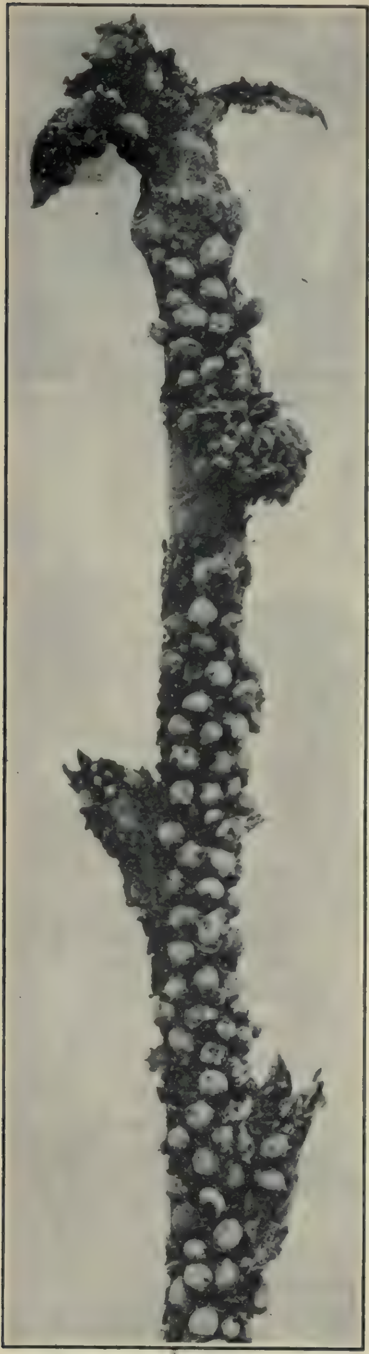

FIG. 28.—A colony of the black peach aphis on peach twig heavily infested by a species of parasitic four-winged fly. Enlarged. (Original.)

tent to which it may be diluted makes the spray compare favorably in cost with other contact sprays. Nicotine is extracted from refuse tobacco, principally stems, by different commercial concerns, and is put on the market in several grades and strengths. The 40 per cent nicotine sulphate is the solution principally used, although weaker grades of nicotine may be employed provided care is taken that the spray be made so as to contain not less than 0.05 or 0.06 per cent of actual nicotine.

Nicotine may be added either to the winter-strength lime-sulphur solution for the San Jose scale or to the dilute lime-sulphur solution and arsenate of lead spray employed in the control of insects and diseases of fruit and foliage. It may also be used in Bordeaux mixture and arsenate of lead spray without interfering with its effectiveness or in an arsenate of lead, milk of lime, and water spray. In orchard spraying the 40 per cent nicotine sulphate is used at the rate of about three-fourths of a pint to 100 gallons of water, lime-sulphur solution, or Bordeaux mixture. When used in water the addition of soap at the rate of 4 or 5 pounds to 100 gallons adds much to its spreading power and efficiency. Soap should not be used with lime-sulphur solution, but may be used in Bordeaux mixture. Where only a small quantity of spray is required the nicotine sulphate may be used at the rate of 1 teaspoonful to a gallon, or 1 ounce to 8 gallons of soapy water.

HOMEMADE NICOTINE SPRAYS.

Where tobacco stems or refuse tobacco are available it is practicable to make nicotine sprays at home. Owing to the variation in nicotine content of tobacco refuse, there is danger of having the spray too weak on the one hand or stronger than necessary on the other.

The following table, adapted from Bulletin 208 of the Virginia Agricultural Experiment Station, illustrates the variation in nicotine content of tobacco stems, refuse, and various kinds of tobacco, and may serve as a guide to those planning to make decoctions from tobacco refuse at home:

Formula for making nicotine extracts.

Lab. No.	Kind of tobacco.	Where from.	Nicotine.	Number of pounds per 100 gallons necesary to make solutions containing different percentages of nicotine.	
			Per cent.	*0.06 p. ct.*	*0.05 p. ct.*
1	Light stems	Richmond, Va	0.481	145	121
2	do	Danville, Va	.609	110	91
3	Sweepings	do	.884	74	62
4	N. L. Orinoco	Appomattox, Va	5.535	12¼	10⅓
5	Olive	Powhatan, Va	3.367	19½	16¼
6	Light	Danville, Va	2.984	22	18
7	Sweepings	Louisville, Ky	.753	91	85
8	Smoker	Chatham, Va	2.306	28¼	23½
9	Wrapper	do	3.05	21½	18
10	Cutter	do	3.466	19	15
11	Dark	Appomattox, Va	2.835	23¼	19¼
12	N. L. Orinoco	Bowling Green, Va	5.629	11¾	10
13	Medium smoker	Chatham, Va	3.766	17½	14½
14	Common smoker	do	2.47	26	21½

Tobacco decoctions can be made conveniently in a lime-sulphur cooking plant, being heated either by steam or by fire under open kettles. The proper quantities of refuse tobacco and water should be placed in the container and the water heated to about the boiling point, after which it should be allowed to cool. Where steam is used a slight increase in water will occur, and a slight decrease where fire is used, although the variation usually will be negligible. Heating the decoction by either method may result in a slight loss of nicotine, especially if the water is allowed actually to boil.

Another method is simply to soak the tobacco refuse in water for 24 hours with frequent stirrings, using a barrel, vat, or other suitable container. This method removes about the same amount of nicotine (70 to 80 per cent) as does the heating process. After the heating or soaking has been completed the decoction should be strained to remove fragments of leaves, etc., and if pressure can be applied to the mass of refuse some additional liquid will be obtained.

Reference to the table will indicate the amounts of several types of refuse which should be used to produce an effective aphid spray. Probably in most cases the refuse at hand can be considered as belonging to some one of the types indicated in the table. Observations as to the effectiveness of the spray should be made, however, so that it may be strengthened if needed.

In this connection it should be remembered that the stems from which the extract has been made have a value for fertilizer purposes of about $10 per ton. With tobacco refuse and stems costing about $20 per ton, the spray solution will cost approximately 1 cent per gallon, the fertilizer value of the extracted refuse covering the cost of labor, etc., in the preparation of the spray.

Tobacco sprays should be made up as needed, since after a day or so fermentation begins.

SOAP WASHES.

Washes made of fish-oil[1] or laundry soap are effective against aphids, and are especially suitable for use on a small scale where only a few plants are to be treated, although fish-oil soap washes are used by many orchardists in the treatment of aphids, the pear Psylla, etc., and compare favorably in cost and effectiveness with nicotine and kerosene emulsion sprays. Both potash and soda fish-oil soaps are on the market. Potash soap is softer and hence there is less trouble in dissolving it in water. Soda soap usually must be sliced and dissolved in hot water before use.

Fish-oil soap of different brands varies greatly in water content, so it is not possible to indicate the precise quantity of soap to be used with a given amount of water for all brands of soap. However, since a statement, on the label, of the amount of the active ingredients (soap) and the total inert ingredients is required by the Federal insecticide act of 1910, purchasers are advised of the amount of soap and water present. In general fish-oil soap should be used against aphids at the rate of 1 pound to from 5 to 7 gallons of water, depending upon the amount of water present in the soap.

KEROSENE EMULSION.

Kerosene emulsion is made up in stock solution according to the following formula:

Kerosene	gallons	2
Fish-oil or laundry soap	pound	½
Water	gallon	1

First the soap should be dissolved in a gallon of boiling water, and after the vessel is removed from the fire the coal oil should be added. Then the mixture should be agitated thoroughly for four or five minutes by pumping the liquid back into itself until it becomes a creamy mass and the oil does not separate. The quantities of the ingredients may be increased when a larger quantity of spray is needed. This stock solution is used against aphids at the rate of 1 gallon to 7 or 8 gallons of water. Kerosene emulsion should not be added to a lime-sulphur spray.

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[1] The name "fish-oil soap" is now used in place of "whale-oil soap," since most of the soap on the market is made of fish oil.

SPRAYING FOR APPLE APHIDS.

Experiments made by the Bureau of Entomology and several of the agricultural experiment stations, notably those of Colorado and Oregon and the Geneva, N. Y., station, show that the aphids attacking the fruit and foliage of the apple are best controlled by spraying in the early spring just as the buds are breaking to destroy the stem-mothers. At this time the insects are hatching from the winter eggs, and are so exposed that one thorough treatment should destroy from 95 to 98 per cent of them and prevent their increase to such an extent that they will not cause serious injury later in the season. This applies especially to the oat aphis, the rosy aphis, and the clover aphis.

In the case of the green apple aphis, which lives on the apple throughout the year, the suppression of stem-mothers in the spring does not always guarantee freedom from this insect during midsummer, and supplementary treatments sometimes are desirable. In the case of young orchards, where the green apple aphis is principally to be considered, the bud spray should be given, but additional applications should be made in summer if found necessary.

Figure 29 illustrates the condition of apple buds when the first spraying should be done, and figure 30 shows the buds too far advanced for successful work, as the aphids have penetrated the spreading leaves and are very hard to reach. In the bud spray the nicotine may be used in the winter strength lime-sulphur solution employed for the San Jose scale, thus effecting the control of both insects by the one application. If the bud spray has been omitted and the aphids are present in numbers, 40 per cent nicotine sulphate should be used in the dilute lime-sulphur solution which is used for the first scab spray and also for the codling moth spray following the dropping of the blossoms. These later applications, however, are not nearly so valuable as the bud spray and merely serve to check the insects.

In spraying apple aphids very thorough work is essential, with good pump pressure, so that the spray may be driven as much as possible against the insects. Results in spraying will vary, depending upon the size of the trees as affecting the thoroughness of the application. On large trees results are frequently less satisfactory than on medium and smaller trees.

Spraying in the fall for the destruction of the fall migrants and the egg-laying females has been tried to a limited extent, but the adequacy of the treatment has not yet been proven.

Annual bud spraying of apple orchards would appear to be good practice, and over a series of years would no doubt prove profitable. This is especially true of varieties subject to "fruit spots" or "stigmonose," since these troubles have been shown by the Bureaus of Plant Industry and Entomology to be due, in part at least, to the activities of aphids.

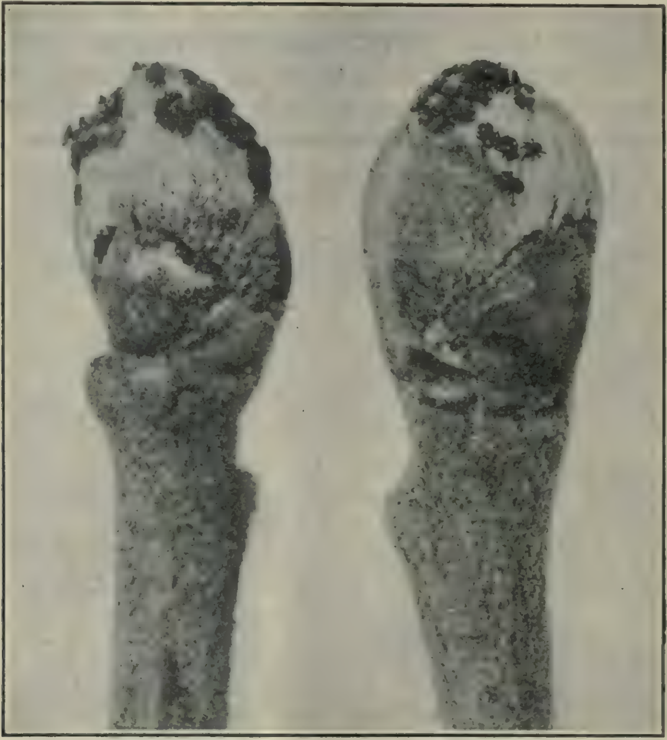

FIG. 29.—Young stem-mothers of an apple aphid and condition of buds when the bud spraying should be given. Enlarged. (Original.)

CONTROL OF APHIDS ON PLUM, PEACH, CHERRY, ETC.

The several aphids which occur on plum, as well as the green peach aphis, pass the winter on the trees in the egg stage, hatching in the spring about the time when foliage appears. None of these species curls the foliage to the same extent as do some of the apple aphids, and thorough spraying of the trees when the insects are in evidence usually will be satisfactory. Nevertheless spring spraying against the stem-mothers is desirable in orchards where the insects have been troublesome regularly or where winter eggs are seen to be present in numbers.

The black peach aphis, which winters on the roots of the peach, should be treated as soon as the insects are observed to be present on the foliage and twigs, and in regions where they are likely to be troublesome, as on nursery stock in sandy situations, careful watch should be made for their first appearance.

The black cherry aphis is likely to be in evidence each year on cherries. The insect winters on the trees in the egg stage and the eggs hatch somewhat in advance of the opening of the buds. Since this species causes a decided curling of foliage so that later treatments are not satisfactory, the effort should be made to destroy the stem-mothers as the buds are breaking.

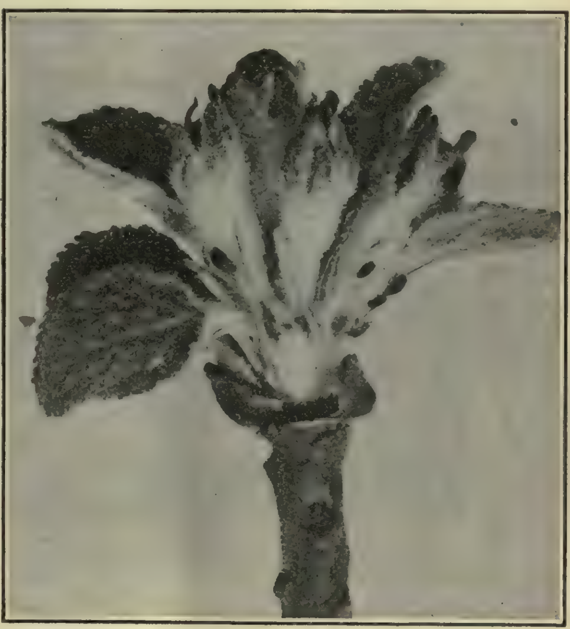

FIG. 30.—Young apple shoot too far expanded for successful aphid spraying. Enlarged. (Original.)

DESTRUCTION OF WINTER EGGS.

Considerable experimenting has been done with sprays during the dormant period of trees to destroy the winter eggs of aphids (fig. 8), on the shoots, twigs, and branches. Thus far results have not been satisfactory, and while sprays may result in the destruction of some of the eggs, serious aphid injury occurs very frequently in orchards well sprayed for the San Jose scale.

In the course of pruning young trees it is often possible to remove many shoots covered with eggs, which should be destroyed.

CONTROL OF APHIDS ON CURRANT, GOOSEBERRY, AND GRAPE.

All of the important aphids attacking the currant and gooseberry pass the winter on these plants in the egg stage, the stem-mothers hatching as the leaf buds are opening and soon causing the leaves to become more or less pitted or curled. It is especially important, therefore, to spray as the shoots are pushing out, to destroy the stem-mothers before they are protected by the distorted foliage. In spraying for these insects later in the season the liquid should be directed upward to wet the insects on the underside of the leaves.

The grapevine aphis, while often abundant on the terminal growth, is rarely very injurious. It is much subject to parasitic and predatory enemies, and migrates from the grape to Viburnum in early fall. When so abundant as to require treatment, any of the contact insecticides may be used.

CLEAN CULTURE.

As the reader will have learned, most aphids have a winter and early spring host plant, and from this they migrate to other plants, on which they subsist for several weeks or months during the summer. In most instances this alternation of food plants is essential to the life of the species, and in general the aphids are most troublesome in regions where alternate hosts are present in abundance. Often one or more of the host plants are of little or no economic importance in the locality, and in some cases are troublesome weeds. The destruction of worthless plants is desirable and should serve materially to reduce the aphids in question. Thus, in the case of the rosy aphis, the alternate food plants of which are species of plantain, the destruction of these in and about orchards is especially desirable, and should be a part of the remedial work against this pest in localities where it is more or less chronically injurious.

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THE DRAINAGE OF IRRIGATED FARMS

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FARMERS' BULLETIN 805

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

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MANY acres of irrigated land have become waterlogged. These must be drained before they can be brought back into use.

Much irrigated land contains an excess of alkali salts, and underdrainage is the basis of the process for their removal.

Water which percolates deep into the soil following irrigation often raises the water table to the height of the plant roots, where it may remain to the detriment of plant growth. Underdrainage will remove this useless water. If in sufficient quantities, water so removed may be used again in irrigation.

Seepage or storm water from adjacent tracts, or water released in the soil by spring thaws, may escape either through surface drains or through underdrains.

Underdrainage prevents the heaving of soil by frost, and permits its ventilation. It makes possible a warmer soil, permits deeper cultivation, and, by allowing the plants to develop a deeper and more complex rooting system, actually increases the available moisture in the soil, instead of decreasing it; by the same means it increases the available plant food.

Methods of draining irrigated farms are described in this bulletin.

DRAINAGE OF IRRIGATED FARMS.

CONTENTS.

	Page.		Page.
Need of drainage on irrigated lands	3	Construction methods	18
Beneficial results of draining irrigated lands	4	Devices	22
Practical drainage requirements	8	Costs	26
Required depth of drains	9	Alkali reclamation	26
Spacing and location of drains	12	Maintenance	29
Types of drains	14	Necessity and advantages of cooperation	30
Sizes of drains	16	Conclusions	31

NEED OF DRAINAGE ON IRRIGATED LANDS.

THE drainage of irrigated lands differs from the drainage of wet lands generally in that it is undertaken to protect or reclaim from injury lands which have been reclaimed from their naturally desert condition at considerable expense and have been productive. The drainage of such land means not merely an addition to the productive area but the saving of the original investment in such land in the farm of which it is a part and in the water supply for irrigation.

Practically every valley where irrigation has been carried on for any considerable length of time has lands in need of drainage. Several classes of land in the irrigated section require artificial drainage in order to be fitted for crop production.

There are natural swamps, but these constitute a minor portion of the area under consideration. They are located chiefly near lakes or watercourses and represent surface accumulations of water. They usually are given over to tule growths, bulrushes, and willows.

Other naturally wet areas are those at the foot of mountains, benches and steeper slopes, produced by seepage from precipitation and from melting snows in the mountains or by springs fed from the same sources.

Of more importance than either of the foregoing, however, are the man-made swamps, the products of irrigation. The area of such lands constitutes by far the greatest portion of the entire area in need of drainage. Lands accustomed to a very limited supply of water from natural precipitation have been drenched with water and subjected to additional supply from leakage from reservoirs, canals, and ditches. Some areas have been converted into veritable swamps; others have become waterlogged, so that they are impassable by man or beast and unproductive of useful vegetation; and still others have passed from a condition of high productivity to one fit only for wet pastures (fig. 1). These conditions are readily recognizable, and the need for drainage is evident, but the result of overirrigation manifests itself often in an accumulation of alkali salts on or near the ground surface, without any apparent wetness (fig. 2). Drainage is the only cure for the latter condition.

As often as not the lands injured by irrigation are not those on which the water is applied, but lower lying lands injured by the seepage from the higher land.

In addition to the foregoing there are natural alkaline areas that never have been farmed. The reclamation of these lands must be based on underdrainage.

BENEFICIAL RESULTS OF DRAINING IRRIGATED LANDS.

As the fundamental basis of all other benefits drainage removes excess water from the soil, whether on the surface or contained as free water within the pores of the soil.

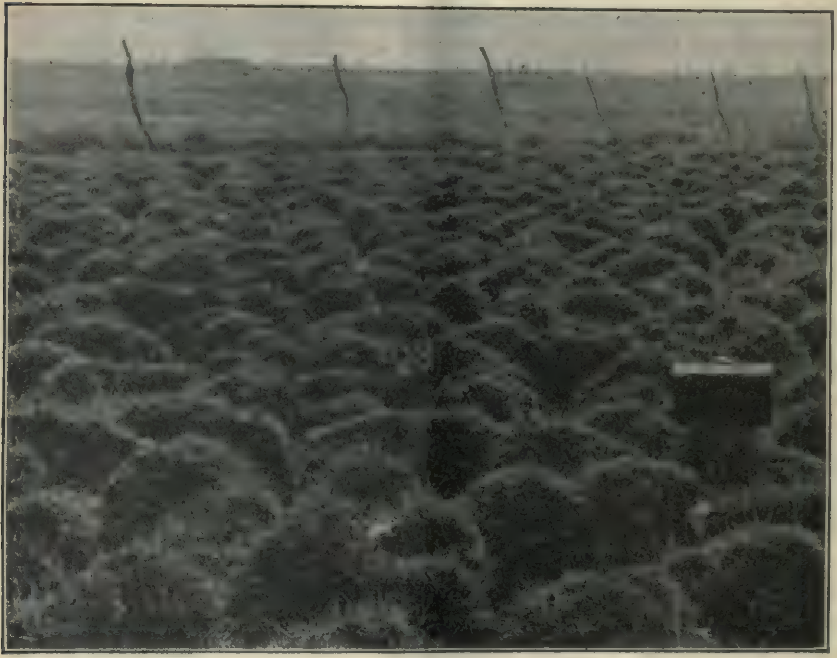

FIG. 1.—Bog produced by overirrigation.

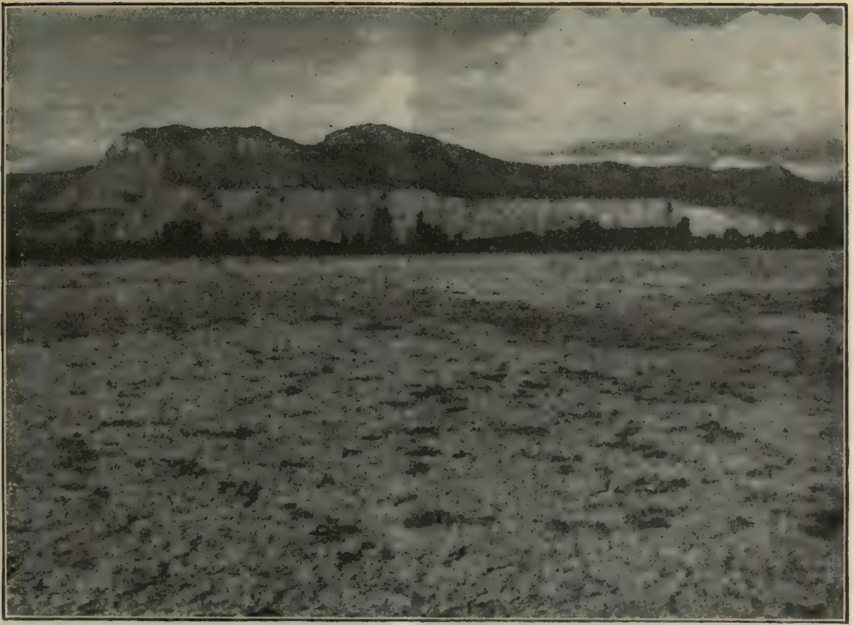

FIG. 2.—An alkaline barren absolutely devoid of vegetation, formerly cultivated but ruined by overirrigation.

In many instances irrigated land contains an excess of alkali salts and underdrainage is the basis of the process for the removal of these harmful salts. All of these salts are soluble in water and the soil water usually is charged with them so that in effecting its removal the salts in solution are removed. Where surface accumulation of salt powder or crystals has taken place, it usually is desirable to apply water artificially to leach out the salts.

Precipitation, which plays such an important part in drainage problems in humid sections, is of little importance in the irrigated section, but there are occasional heavy rains that are capable of doing damage by raising the ground-water table at just the wrong time. Underdrainage will take care of most excessive precipitation.

Of far greater importance than precipitation is the water lost by deep percolation following irrigation. In undrained soils this often brings the water table up around the plant roots where it may remain for a dangerous length of time. Underdrainage will take care of such excess unless unusually wasteful methods are used in irrigation.

Water making its way onto a tract by waste or seepage, or storm water from an adjacent tract, may be taken care of without injury to the tract by underdrainage supplemented by surface drainage, if desirable.

A sudden change of temperature in the spring often supplies a surplus of water by the melting of snow or of frozen ground. Underdrainage takes off such water.

Underdrainage also prevents the heaving of soil by frost.

It is manifest that air and water can not occupy the same space at the same time and that water, being heavier, will crowd the air out of the soil pores. It is well known that for proper plant development the presence of air in the soil is as important as a supply of moisture. When underdrainage is installed and the excess water moves downward, the air is admitted into the soil and the proper balance between the air and moisture content is restored.

FIG. 3.—Wet pasture after reclamation by drainage.

When organic matter decays in the absence of air, as in waterlogged soils, gases and other substances are sometimes formed which are injurious to plants. This is avoided by underdrainage, which enables the air to enter the soil.

It takes much more heat to raise the temperature of a given volume of water one degree than it does to raise the temperature of the same volume of air to the same extent. Underdrainage makes possible a warmer soil. This result is of importance at all seasons of the year, but particularly so in the early spring. Underdrainage induces earlier germination and the season is made both earlier and longer.

Another early spring advantage of underdrainage is that plowing may be done much earlier and with greater ease.

Underdrainage improves the texture of the soil itself by developing the drainage pores, promoting root development, permitting deeper cultivation, etc.

Underdrainage increases the available depth of soil, which is equivalent to increasing the available acreage without adding materially to the amount or cost of manipulation.

Underdrainage provides a control over irrigation and permits a more economical use of water, preventing surface waste when large heads are used.

Underdrainage increases the available moisture in the soil itself instead of decreasing it, as is feared by many. This is due to the fact that the plants develop a deeper and more complex rooting system which comes in contact with a greater number of soil particles and consequently a greater surface of water film area.

For the same reason, underdrainage increases the available quantity of plant foods (figs. 3 and 4).

Deep rooting in the spring also insures against drouth. Plants growing on drained soil are not so liable to injury due to water shortage in the summer. This is of special importance on tracts that have late water rights, since crops are more likely to be matured before the supply is cut off; but failing this, they have an increased underground supply of moisture due to underdrainage.

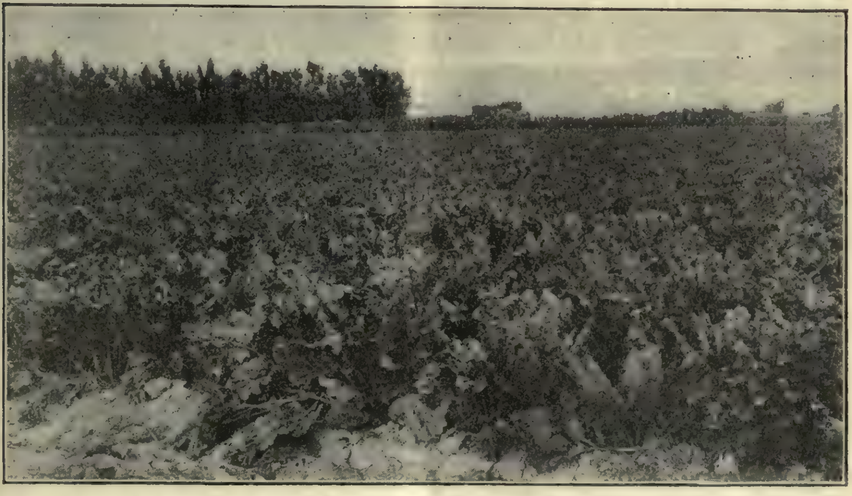

FIG. 4.—Sugar beets growing on tract reclaimed by drainage.

Beneficial bacterial activity is largely suspended in cold, wet soils, and such activity is necessary to the manufacture of plant food and its conversion into available form. Underdrainage increases the zone and intensity of such bacterial activity.

The water developed by underdrainage is brought to the ground surface where it is available for re-use either by the owner or by others to whom it may be rented or sold. Drainage water, even from tracts that have been salty, may not be injurious if used on drained land, since the salt content is reduced rapidly to a safe percentage, but this should be determined before such water is used.

PRACTICAL DRAINAGE REQUIREMENTS.

To determine the various factors of design it is necessary to make a careful study of subsurface conditions, often to a depth of many feet. Subsurface studies may be made by means of test pits and borings. On account of the high cost of test pits, only a few will be dug ordinarily, but it is customary to make a large number of borings. Test pits may be dug with shovels, and picks if necessary; but usually it is feasible to use telephone shovels and spoons and make a hole only a foot or so in diameter. A test pit affords a much better idea of the subsoil than a boring and is especially useful in giving an idea of the drainage capacity of the soil. For determining depth to the water table, fluctuations of the latter, depth to and the thickness of various substrata, a boring is nearly as satisfactory. It is even possible in this way to obtain a fair idea of the character of the various strata. Borings may be made with an auger consisting of a carpenter's bit welded to a half-inch gas pipe, provided with a handle consisting of a T and two short pieces of gas pipe. The gas pipe stem should be cut in 4-foot lengths so that it may be extended as the depth of boring increases. The screw tip and the sharp wings should be removed from the bit. Figure 5 shows such an implement. Care must be used to secure the type of bit shown, as an ordinary twist bit is not satisfactory.

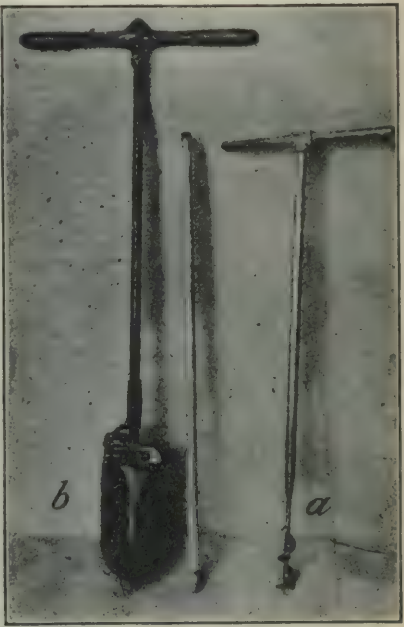

FIG. 5.—*a*, Soil auger suitable for making test holes. *b*, Earth auger suitable for boring observation wells and relief wells. The latter is adjustable and the jaws open for discharging the dirt.

In making soil borings only a turn or two should be given at a time, the soil being removed and examined by augersful. The character of the soil may be determined by the way the auger cuts, the difficulty in pulling it out, the way the soil holds together when being removed from the auger, and by rubbing the soil between the fingers or gritting it between the teeth.

If it is desired to observe the behavior of the ground-water table over a more or less extended period it will be necessary to install observation wells. These may be bored with an earth auger or a post-hole auger (fig. 5), and ordinarily must be lined to prevent filling. The most suitable casing is made of ordinary galvanized downspouting perforated at frequent intervals on several sides with a nail. The casing should extend a half foot or more above the ground level and should be covered with a tin can. A round block of wood should be fitted into the lower end to prevent mud from rising in the casing.

A number of such wells should be installed on most irrigated farms so that the owners may have immediate notice of coming injury and be prepared to combat it before crops are lost and before soil conditions become bad, making construction costs much higher than they should be. Men have declared frequently that the ground water on their farms was not within 20 feet of the surface when, as a matter of fact, it was within 2 or 3 feet.

Every irrigated farm should be supplied with a soil auger such as that described above and it should be used intelligently in connection with irrigation practice. Many farmers in the irrigated section consider a soil auger of as great importance as any tool or implement they possess.

The making of subsurface studies for the actual design of a drainage system, however, ordinarily should be left to some one trained in drainage work, as there are few projects so small or apparently so simple as not to warrant the employment of such a person. Surveys must be made in order to design an economical and efficient system, and it is preferable that the subsurface studies be made at the same time so that the surface and subsurface data may be correlated properly.

REQUIRED DEPTH OF DRAINS.

One of the first questions asked by the landowner contemplating drainage of irrigated lands is "How deep should the drains be?" The matter of depth is one of the most important factors, but a depth perfectly satisfactory in one case may render a drainage system unsuccessful in another. In general it may be said that drains in the arid section must be deeper than those in humid soils. The soils themselves usually are deeper and the plant-root systems extend to greater depths. But more important than either of these considerations is the fact that most irrigated soils contain salts that are harmful to crop development when present in excess on or near the ground surface. These salts may become concentrated on the ground surface, even though the depth to the water table be several feet. The soil moisture rises several feet above the free water table in the soil, and this moisture is charged with harmful salts wherever the ground water contains such ingredients. The harmfulness depends in a large measure upon the concentration of the soil solution, so a given amount of salt may become harmful if transpiration or evaporation removes a portion of the water and leaves the salts. It is important, therefore, to lower the water table deep enough that the plant roots will not feed in salty solutions. The height to which water will rise by capillary attraction varies with the kind of soil, being greater in the case of fine-grained, compact soils than in loose, coarse-grained soils. The height of rise in clay often is twice as great as that in sandy loam. If the sand be very fine, however, the height of rise may be nearly as great as in clay. Experience throughout the entire arid West leads to the conclusion that drains rarely should be placed at depths less than 6 feet; that is, the distance to the water surface in the drains should not be less than 6 feet.

The subsoil is almost never homogeneous, however, and any change in formation has an important bearing on the required depth of drain. This is true whether the change is from a compact to a loose formation or vice versa. It is especially true if a stratum of either more or less pervious material is found within, say, 10 feet of the ground surface. For instance, assume that the tract under consideration is injured by seepage from higher land; that the first 2 feet of soil consist of loam, the next 4 feet of clay, and that under the clay is a layer of sand a foot thick, followed by more clay. The depth to the top of the sand is, therefore, 6 feet, and if a drain is installed 6 feet deep it will lie on top of the sand layer. As may be expected, the damaging water seeping from the higher land moves through this sand layer, therefore the drain fails to intercept it and the drainage system is a failure. Moreover, the sand makes a very unstable foundation for a drain and the tile is likely to get out of alinement, off grade, or even to be up-ended and filled with sand. Even if none of these things happens, there is great danger of sand and silt making their way into the tile and obstructing it. It is quite evident that the drains should be laid on the clay underlying the pervious stratum or perhaps be bedded slightly into the clay. In that case there would be no danger of the tile getting out of position and the drain would be very effective. Thus an additional foot in depth often makes the difference between success and failure. It is necessary to know the existing underground conditions in each case before the proper depth can be decided upon.

Much the same situation would arise if the soil were a sand with a hard, impervious layer at 7 feet. Water reaching the tract by seepage from higher land would be likely to move along the impervious layer, and if a drain be laid at a depth of 6 feet the water would continue to pass under it and the tile would be likely to become displaced and obstructed. Manifestly the correct practice would be to lay the tile on or slightly in the hard, stable stratum.

Even if the soil be homogeneous the question of depth is of great importance. In such a case the effectiveness of the drain increases with the depth. A line drawn along the surface of the water table from one drain to the next is a curve which rises rapidly away from the horizontal near the drains, but is very flat midway between drains (fig. 6). If the depth of the drains be increased the depth to this curve is increased at every point, but not equally so. Thus with drains at a given distance apart, the drainage is improved greatly over the whole area, or the same minimum depth may be obtained with the drains placed farther apart. It becomes a plain economic problem, therefore, and costs must be compared carefully to determine whether a few expensive, deep drains are cheaper than a greater number of comparatively shallow drains. Drains 8 to 10 feet deep, and even more, have been installed, and, although their cost has been much greater per unit of length than that of shallower drains, they have been so much more effective, requiring fewer lines, that they have been more economical.

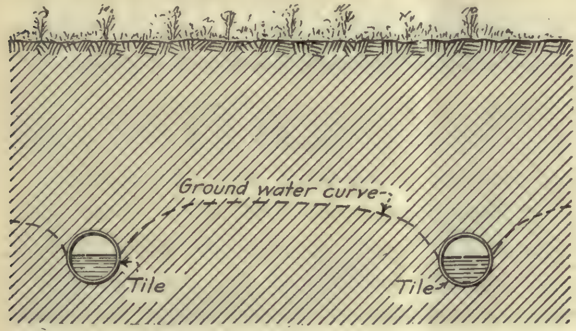

FIG. 6.—Cross section through soil, showing profile of ground-water surface between drains.

It is not always true, however, that the effectiveness of a drain increases with the depth. For example, in a subsoil that changes from a sand to a compact, relatively impervious clay at 6 feet, it would not be wise to install drains at a depth of 10 feet since they would then be laid in material that yields very little water, and the effectiveness of the system would be little greater than if the drains were installed only 6 or 7 feet deep, and the expense of the extra cutting would be wasted. There is even a possibility that the drains would be ineffective at such a depth. If the subsoil is a joint clay, however, it will be found to drain as readily as sand.

Drains having a depth of from 2 to 4 feet, such as are employed in humid sections, are practically worthless in the reclamation of irrigated lands.

SPACING AND LOCATION OF DRAINS.

The landowner contemplating drainage invariably asks the question, "How far apart should drains be placed in draining irrigated lands?" This question, like that as to the proper depth of drains, does not admit of a definite answer. The question is more one of location than of spacing, and the two factors must be considered together, the latter usually depending largely on the former.

The damaging water may have several sources of supply and, as likely as not, it will be moving laterally through the soil instead of percolating downward from surface application. The chief sources of supply, aside from direct precipitation and the melting of snow on the ground surface of the tract itself, are downward percolation of the excessive water used in the irrigation of the tract itself, surface run-off from higher land, supplied as precipitation, melting snow, irrigation or seepage brought to the surface; lateral underground seepage from the irrigation of higher lands, and losses from ditches, canals, and reservoirs; and, in some instances, direct natural seepage from the mountains.

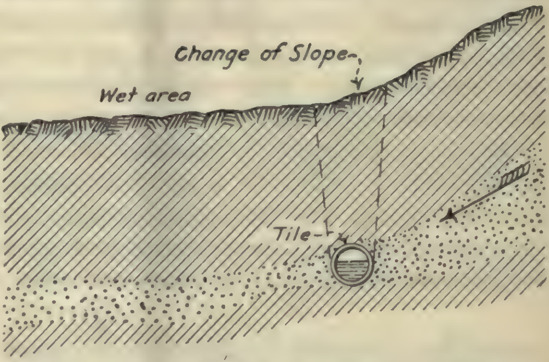

FIG. 7.—Drain properly laid to carry off seepage.

Ordinary drainage methods would serve for the removal of the moisture applied directly to the tract itself, from whatever source, but this constitutes the smallest part of the problem. In the majority of instances it is necessary to intercept lateral seepage from higher lands before the damaging water reaches the tract in question. Often a combined system is necessary.

In the interception of lateral seepage the question of location is of highest importance, while the question of spacing is of little or no consequence. One properly placed line of drain will be more likely to reclaim successfully the injured area than a dozen lines placed at random, however closely they may be spaced. It is not unusual to find that a single drain will reclaim a 40-acre tract, when it can be located so that it will intercept the damaging water along the line of its appearance as seepage. For instance, consider a tract of land injured by seepage from higher land. The seepage appears usually along a belt at the change of slope from a steep to a lighter grade. If the subsoil be examined, it probably will be found that there is a more pervious stratum of material, say sand, at a depth of several feet. This stratum of sand acts like a pipe line, leading from the source of supply and pouring the damaging water into the lower land, since the flatter slope is insufficient to carry the water away as rapidly as it reaches the tract. Now, if a drain is located just below the line of the change of slope, at or near the upper edge of the wet area, and is at sufficient depth to cut through the sand layer, the flow of water will be intercepted and the water will be carried away in the drain without doing damage to the land (see fig. 7).

The conditions must be studied thoroughly and to a sufficient depth to make sure that there is no pervious stratum underlying the drain through which water may seep to the lower land. In case such a stratum exists at a depth of, say, 10 feet or more, it will not be feasible ordinarily to reach it with a drain line, but a drain of ordinary depth may be installed and relief wells bored in the bottom of the trench to the stratum, thus providing passageways through which the water may rise and reach the drain (see fig. 8).

After an intercepting drain is installed and the seepage from outside sources is cut off the natural drainage of the tract usually is sufficient to take care of the water applied to the tract itself, but if this is found to be not the case it will be necessary to install drains to remove the excess water. The question of spacing may come in here, especially if the tract be rather flat and has a fairly uniform surface. If the subsoil be clay, with a sand stratum at a depth of several feet, drains 400 to 500 feet apart will serve. If no sand stratum be present it may be necessary to reduce the spacing to from 200 to 300 feet, but if the subsoil be sand the spacing may be greater than 500 feet, and in the case of gravel subsoil the spacing may be a quarter of a mile or more. Where the subsoil was a coarse gravel some very satisfactory systems have been installed with drains every half mile, with the depth from 6 to 8 feet.

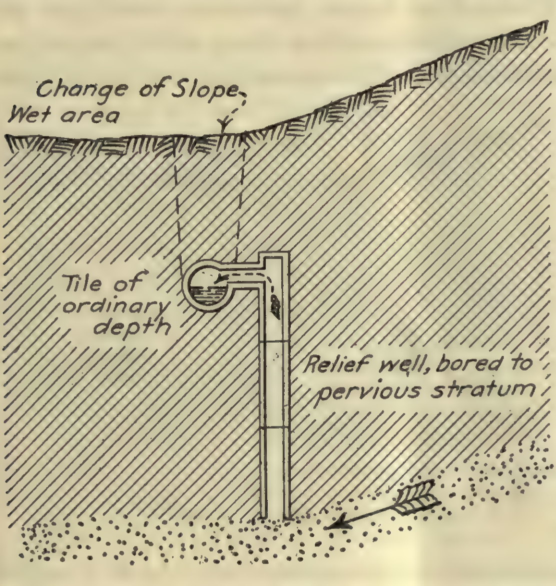

FIG. 8.—Relief well.

If the tract in question be cut up by swales and depressions the installation of a regularly spaced system is not advisable. Generally, in such a case, the drains should be located in the swales (see fig. 9). The latter arrangement has some exceptions in cases where the subsoil underlying the swales is less pervious than that underlying the higher ground. Often it is necessary to have the drain lines run at the edge of the swales, two lines being required for each swale (see fig. 10). It has even been found necessary in some instances to locate the drains on the higher land.

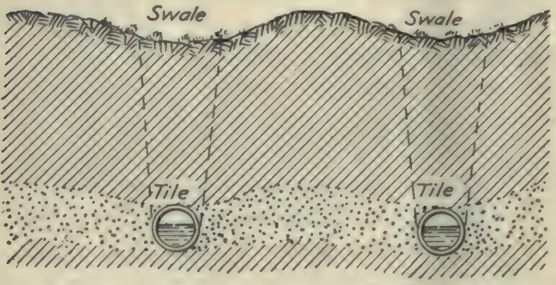

FIG. 9.—Cross section through soil, showing method of draining swales.

The installation of drains below the wet area, with the idea of drawing out the water, should be attempted only when the subsoil is a coarse gravel, and not even then if the land above the wet area has a greater slope.

As a rule drains in the irrigated section run across the natural slope rather than down the slope. The reason for this is that with the drains running down the slope the damaging water would be moving in the same direction that the drains run, and consequently very little water would reach the drains, the remainder continuing to reach the lower land and doing damage. The only land drained would be that in the immediate vicinity of the drain lines.

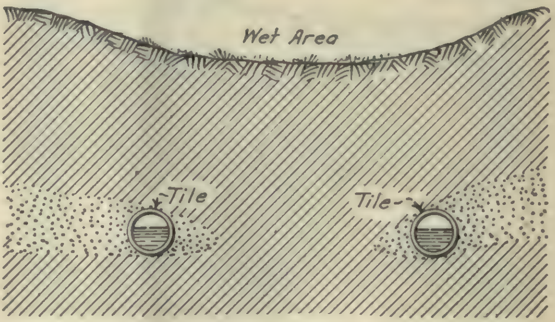

FIG. 10.—Cross section showing application of double line of tile. This is made necessary by the absence of pervious material underlying the middle of the swale.

The average amount of tile per acre ordinarily employed in farm drainage in the irrigated section is about 100 feet. At this rate a mile of tile will drain about 53 acres of land, or a square mile of land will require about 12 miles of tile.

TYPES OF DRAINS.

There are two general types of drains in use in the irrigated section—the open ditch and the covered drain. Since this discussion deals only with the individual farmer's problem, no consideration will be given to the large open canals used for outlets in community or district systems. The open ditch, as its name implies, is merely a waterway cut into the soil so that it will receive the underdrainage from adjacent land. The covered drain consists essentially of an underground conduit for the collection and transportation of subsurface water. It is superior to the open ditch. The only reason for using the latter is strictly one of economy, and a decision as to the type to be used should be made only after all factors having a bearing on the subject are considered carefully.

The open ditch itself takes up considerable space, and the material removed in building it usually is of such a quality that it is not wise to spread it over the surface of the adjacent land, so additional space is lost. Moreover, it is not safe to irrigate land close to such a channel, as there is danger of the water breaking into the ditch, with consequent injury to it and the land. Even a very small ditch may require that a strip of land several rods in width shall be rendered useless for agricultural purposes, so that an effective drainage system may reduce materially the available acreage of a farm. To keep an open ditch open the sides must be made sloping, not steeper than one horizontal to one vertical, and to prevent the growth of vegetation and the accumulation of mud, etc., in the channel from obstructing it the bottom width should be not less than 4 feet, except in gravel or stiff clay, where it may be 3 feet, so it becomes necessary to excavate much more material than in trenching for covered drains. But in spite of careful design, construction, and operation open ditches are sure to require a great deal of maintenance and repair, and the expense for these often amounts to more in the long run than the extra cost of covered drains.

Open ditches are unsightly and provide harborage for obnoxious weeds and breeding places for injurious and disagreeable insects. Their presence is a constant source of danger to farm animals. They cut up the farm into inconvenient and irregular shapes and require the installation of farm bridges and flumes in order to facilitate communication between the various parts of the farm and for the conveyance of irrigation water and waste water from tract to tract. Covered drains, on the other hand, are not subject to these objections. They take up no valuable space, and if properly installed require little or no maintenance. The only way in which difficulty can occur, in connection with vegetation, is the possibility of water roots choking the drains, and this can not occur if lines are kept away from water-loving trees, and if such plants as the sugar beet are not grown directly over the drains.

In order to decide between types of drains, it is proper to add to the estimated cost of open ditches a sum sufficient to pay at current interest rates, a return large enough to pay the annual maintenance, which often is 10 per cent of the first cost, and compare this total with the first cost of covered drains. For instance, assuming that the first cost of the open ditch would be 50 cents per foot and of the covered drain $1.25 per foot, if the maintenance cost is 5 cents per foot per year for the open ditch and the interest rate is 5 per cent, it will be necessary to add $1 per foot to the actual cost to pay for the maintenance. This makes the cost of the latter $1.50 per foot as against $1.25 for the former. When the maintenance cost is considered, the covered drain often will be found actually cheaper than the open ditch and when the desirability of the two is considered there is no comparison.

The most suitable material for use in a covered drain is clay tile. It should be hard burned but not brittle. The 2-foot length is the most satisfactory. The tile should be straight and truly cylindrical in shape. The walls should be smooth and free from serious cracks and blisters. The ends should be free from rough edges and irregularities. The tile should be uniform in size and thickness for any given diameter. The walls should have fairly uniform thickness at both ends and at various points of the circumference. They should be very impervious and have a low porosity. The material from which the tile is made should be free from foreign ingredients, particularly cinders and free lime.

Pole drains, brush drains, mole drains, rock drains, and cobble drains are almost useless in irrigated soils and never should be installed. Lumber box drains have been used to some extent as a substitute for clay tile but their use is a doubtful economy. Cement tile is not generally recommended for the drainage of alkali lands as it is subject to rapid deterioration unless it be made of a very dense mixture that will not permit the penetration of water containing alkali in solution.

SIZES OF DRAINS.

The spacing of drains in the irrigated section usually is much greater than in humid sections and, frequently, a single line of drain may effect the reclamation of a considerable acreage. From this it will be concluded that larger drains will be required in the drainage of irrigated lands. It has been found that they need not be proportionately large, however, since the amount of water which it is necessary to take care of is smaller for a given acreage. In the arid section, there is likely to be a continuous discharge of drainage water throughout the year, and frequently the discharge is very uniform at all times. However, there are certain maximum flows, usually during the period of greatest irrigation application, and it is necessary to provide a drainage capacity that will take care of such flows.

If only the required capacity of the drain were considered, it would be found feasible to do a great deal of drainage with 4-inch and 5-inch tile, but experience has shown that the use of tile smaller than 5 inch is not satisfactory, while 5 inch should be used only for short branch lines or at the upper ends of branch lines. The following table is offered for purposes of comparing the carrying capacity of tile lines of different sizes, on the assumption that all are laid on the same grade.

Relative carrying capacities of tile of different sizes.

One—	Will carry the discharge of—
6-inch tile	Two 5-inch tiles.
7-inch tile	One 6-inch and one 5-inch tile.
8-inch tile	Two 6-inch tiles.
10-inch tile	One 8-inch and one 7-inch tile.
12-inch tile	One 10-inch, one 8-inch, and one 5-inch tile; or three 8-inch tiles; or seven 6-inch tiles; or twelve 5-inch tiles.

As a rule, tile larger than 12-inch in diameter is not used in individual farm drainage.

The size of tile required depends on the amount of water to be carried and on the slope of the drain. The latter can be decided upon when the survey of the land is made and the fall to the outlet is measured. The former is not so easy to determine. It depends on the location of the tract, the nature of the soil, the slope of the ground both on the tract and above it; on the quantity of water used in irrigation and on the method of irrigating, both on the tract and on higher land; on the rainfall and evaporation; on the seepage from reservoirs, canals, and ditches; and on many other factors. Indeed, the determination of the required capacity of a drainage system is the most difficult problem confronting drainage engineers, and demands their best efforts. Intricate measurements and calculations must be made in each instance. It is therefore impossible to give definite instructions in regard to this important matter. It is possible, however, to give a general idea of required sizes based on a wide experience under a great variety of conditions. The following table is intended to apply to fairly uniform land not located at the foot of steeper slopes or benches, nor in pockets or depressions, nor in flat river bottoms where it will receive surface run-off from higher land, nor where it will receive water from deep sources by pressure. The assumed slope of the tile is 2 feet per thousand feet.

Sizes of tile required to drain given areas having different types of soil.

Area of tract (in acres).	Size of tile required.		
	Clay with sand stratum.	Sand.	Gravel.
320	10-inch		
160	8-inch	12-inch	
80	7-inch	10-inch	12-inch.
40	6-inch	8-inch	10-inch.
20	5-inch	7-inch	8-inch.
10	5-inch	6-inch	8-inch.

If the soil be compact clay, a given size of tile will drain larger areas than indicated. If the subsoil be joint clay, the "sand" table should be used. If the drain be located at the foot of a bench or in a gravel pocket, none of the above bases will apply. A better basis for design in such cases is the length of a given size of tile which it is safe to use. A slope of 2 feet per 1,000 feet is assumed, as before. The following table will give a rough idea:

Sizes of tile required for drains of different lengths.

Size of tile.	Maximum length.	
	Sand stratum.	Gravel.
	Feet.	*Feet.*
12-inch	5,580	1,250
10-inch	3,350	750
8-inch	1,790	400
7-inch	1,250	220
6-inch	800	180
5-inch	450	100

For greater slopes smaller tile is required, and for flatter slopes larger tile is necessary, the variation in capacity being as the square root of the slope. If lumber boxes are used, the openings should be about the square of the tile diameter.

For open ditches the bottom width should be 4 feet and the side slopes should be at least 1 to 1. Thus for a depth of 6 feet the top width would be 16 feet or more, and for a depth of 8 feet the top width would be 20 feet or more.

In the installation of a drainage system it should be borne in mind that the improvement is permanent, and that after the tile is once covered up it is more expensive to uncover and relay it with larger tile than to install a new drain, so it is false economy to cut down on the size of tile. It is much better to err on the side of too great capacity than too small.

CONSTRUCTION METHODS.

In many instances owing to lack of humus the soils of the arid region are very fluxible when wet, and the construction of drainage systems is very difficult and requires painstaking care and ingenuity. Special methods and devices have to be employed, and special machinery has been developed.

Drain lines must be laid out carefully and grade stakes set. The completed drain must be true to grade and as straight as possible. For hand trenching it is advisable to stretch a cord on the ground along one edge of the proposed trench, to obtain good alignment. To insure accurate grade at all points, grade planks should be set up at each station at a uniform height above the grade of the drain, as shown in the illustration on the title page. A stout cord then may be stretched over the middle line of the trench from plank to plank and every point on this cord will be the given height above grade. Grade may be established at one end of each tile with a grade pole having a length equal to the distance from the cord to the proper location for the tile. This may be accomplished by keeping the cord taut by suspending a tile or other weight at each end and measuring down from the cord at the desired points.

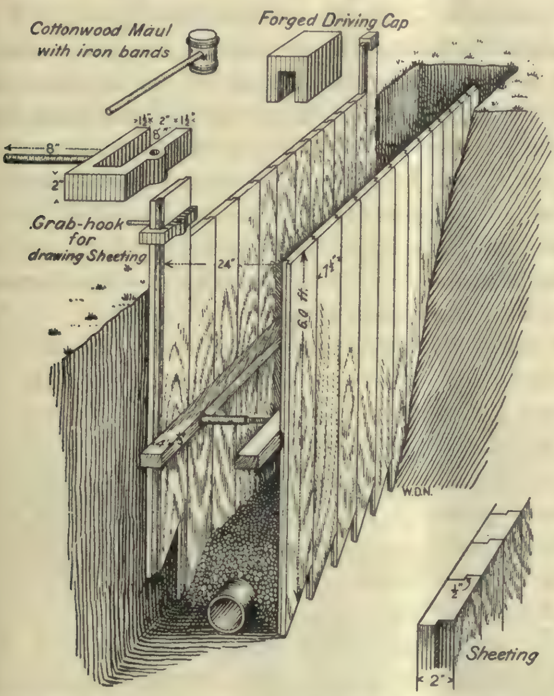

Fig. 11.—Showing shiplap sheeting and method of installation for drains 6 feet in depth. For deeper drains, two sets of timbers and braces must be used.

Construction work always should start at the outlet of each line and proceed up the slope, so that the water developed will drain away.

In installing covered drains either hand labor or trenching machinery may be used. Frequently, on small projects, hand trenching is cheaper, but usually on larger projects machines can do the work more rapidly, economically, and satisfactorily. It is preferable to let a contract for the work to an experienced and capable contractor.

If hand labor is used it usually is necessary to operate with small gangs, ordinarily about a half dozen men to the line, as the trench must be opened from the top to the bottom as rapidly as possible and the tile laid and blinded before caving takes place. The men should work as closely together as practicable and not even the first spading should be taken more than a rod in advance of the tile laying. Each man should remove a spading, moving backward at the same time. The man removing the last spading should also grade the bottom. He should not step on the finished bottom and no one should stand near the edge of the trench, nor should wagons or material of any sort be permitted near the trench. The soil removed from the trench should be placed as far back as it conveniently may be. The tile should be laid at once and blinded by means of a few inches of earth caved from the edges of the trench. If the banks tend to cave off in large chunks or slabs it will be necessary to brace them apart with planks separated by stout crosspieces or trench jacks.

A very troublesome condition is that in which the presence of a wet, pervious stratum near the bottom of the trench causes a lateral and upward movement of the soil in the bottom of the trench. In such a case it is necessary to provide a tight cribbing to shut out the oozing material. A design for such a cribbing is shown in figure 11. It consists of two heavy timbers, held apart by trench jacks, behind which is driven lumber sheeting properly matched and beveled at the lower ends to insure a tight fit. The sheeting may be driven by means of a heavy maul and may be removed with a three-legged derrick and a special grabhook like that shown in the figure.

If the soil in the bottom of the completed trench is so soft that it will not support a man's weight, wooden racks or cradles should be laid under the tile to keep it in line and on grade. If conditions are exceedingly bad it often is advisable to use sewer pipe in place of drain tile, as the bells aid in keeping the line intact. Second quality sewer pipe is suitable and generally may be purchased at about the same price as drain tile. Under ordinary conditions, however, the use of sewer pipe is not recommended, since the cost of freight and hauling is higher than for drain tile and it is heavier and more difficult to handle. Also, in stable ground it is necessary to dig out places for the bells, which considerably increases the cost of trenching.

Tile should be laid with extreme care. The joints should be as close as possible, and if the soil is semifluid and contains much fine sand and silt, it will be necessary to provide some means of keeping the oozing material from entering the tile joints. Almost all the water entering tile lines makes its way through the joints, practically none entering through the walls of even the more porous tile, so the covering for the joints must provide for the ready passage of water. Straw makes a very good filter when new, but it is likely to decompose and form a sticky, impervious mass over the joints. Brush and willows are not satisfactory and render any subsequent removal of the tile very difficult. Graded gravel, ranging in size from sand to pebbles an inch in diameter, makes an excellent filter, but it is not always available. Cinders also are satisfactory. Strips of burlap wrapped about the joints give good service. The custom of laying strips of building paper over the joints can not be commended, since the greatest tendency is for the sand and silt to enter at the bottom and if paper is wrapped tightly entirely around the joints the water itself will be shut out. For genuine quicksand, perhaps the best material is cheesecloth, which should be doubled once or twice and wrapped carefully about the joint. This material soon decomposes, but in the meantime the soil becomes compacted so that the purpose is served.

The more pervious materials should be placed adjacent to the tile.

The backfilling may be done with a plow with three or more horses and a long pole evener, or with a scraper, road grader, or go-devil. Recently power backfillers have been placed on the market. All the soil should be returned to the trench and be banked up over it, so that future settling will not leave a depression over the drain.

In machine trenching it generally is necessary to draw a portable shield after the machine in which the tile may be laid and blinded before caving takes place. Figure 12 shows such a shield in use in trenching in unstable soil. This illustration also affords an idea of the depth of drains required for reclamation of irrigated land. The man in the shield is standing on top of a 15-inch tile. There are several types of suitable trenching machines but, as machine work

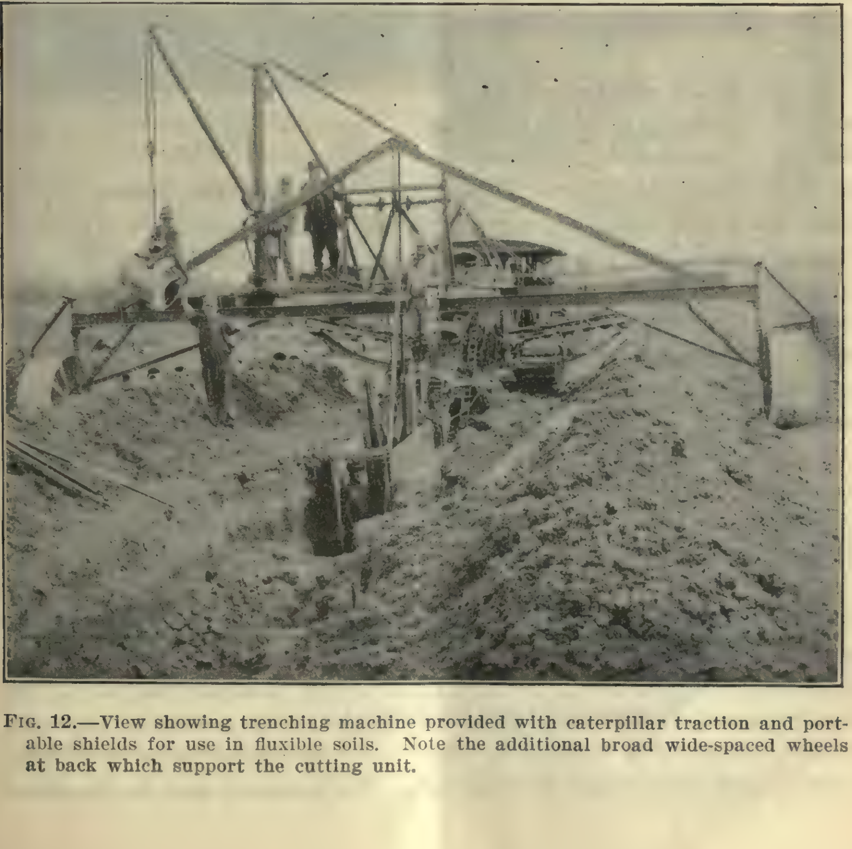

FIG. 12.—View showing trenching machine provided with caterpillar traction and portable shields for use in fluxible soils. Note the additional broad wide-spaced wheels at back which support the cutting unit.

usually is let by contract, the choice of type must be left to the contractor.

DEVICES.

Bulkheads and outfalls.—The outlet of a drainage system should come in for more consideration and attention than usually is given to it. If the tile line discharges into a deep ravine or river channel at some distance above the water level an outfall should be provided. This may consist of a corrugated iron pipe extending far enough out over the bank to discharge the drainage water directly into the stream without striking the bank and causing erosion. The other end should be anchored by means of a concrete wall and a careful connection with the tile line must be made so that water will not find its way along the outside of the conduit. The last few joints between tile should be cemented.

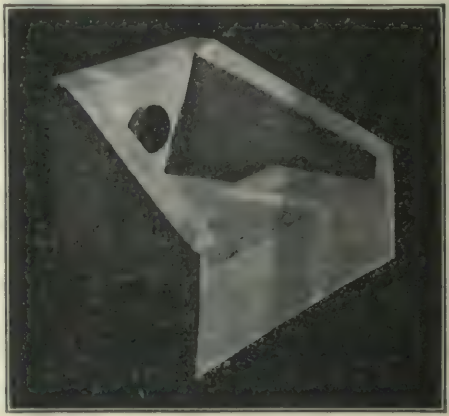

FIG. 13.—Concrete bulkhead for use at outlet of tile drain.

If the drain discharges at or near the water level or bottom of a channel a concrete, brick, or timber bulkhead should be constructed to prevent injury from frost and from the caving of the banks, and to prevent the washing out of the tile line at the lower end. Care should be taken that it has a good foundation, in order that it may not be undermined. Figure 13 shows a cheap and easily built concrete bulkhead. A network of heavy wires or small rods of copper or galvanized iron should be placed across the outlet to keep out small animals.

Manholes.—A change in direction of a line of tile should be made gradually by a smooth curve, or a manhole about 4 feet square should be installed at the point of change. If the soil contain much fine sand, a combination manhole and sand trap should be located at such a point, as well as at every change from a steep to a lighter grade. Such a device serves as an observation well in which the flow may be seen and the general conditions of the system watched. It also serves as a settling basin for any sand or silt that may be carried by the drain, and if the trap be made to extend a foot or two below the drain, a chamber is formed in which a considerable amount of sediment is held until it can be removed. The manhole may be provided also with a surface inlet to make it possible for the drain to take care of surface water and, if desired, to provide for flushing the drain. As a manhole proper it provides a means for the operation of a root-cutting or drain-cleaning device operated by sewer rods. If it is expected that such work will be necessary, the drains should be laid out in straight lines with grades as uniform as possible, and a manhole should be provided at each junction, change in slope from steep to a lighter grade, and on straight sections at intervals of not to exceed 500 feet.

On straight lines a manhole may be made long and narrow, but at a junction or turn it should be made square to facilitate the operation of rods and to prevent the sediment from being carried across the trap. Brick or concrete is preferable, but lumber often is used. Recently a manhole built of corrugated iron has come into use and presents many advantages. When built of lumber, 2-inch material should be used. Figure 14 shows a simple type of manhole, constructed of lumber and so designed that the earth pressure will maintain it in spite of the failure of the nails. In most places the manhole should be provided with a bottom and it always should be fitted with a cover that can be locked down.

Observation wells.—If little sand be present, rendering sand traps unnecessary, it still is desirable to provide for observation of the flow at points throughout the system. Nothing serves this purpose better than a vertical stack of large-sized tile or second-grade sewer pipe, extending from a little above the surface of the ground to a foot or more below the tile line, and having holes cut in the lower

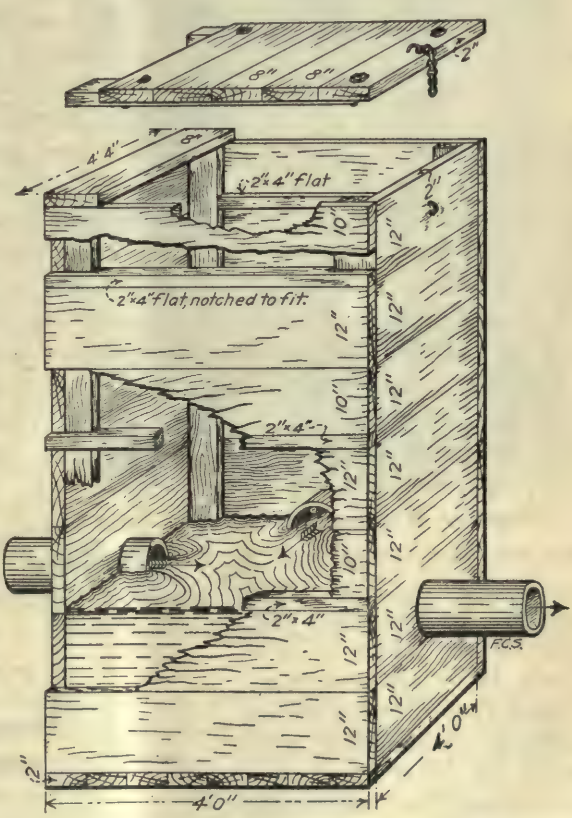

FIG. 14.—Combination manhole and sand trap with cover that does not depend upon nails to hold it together.

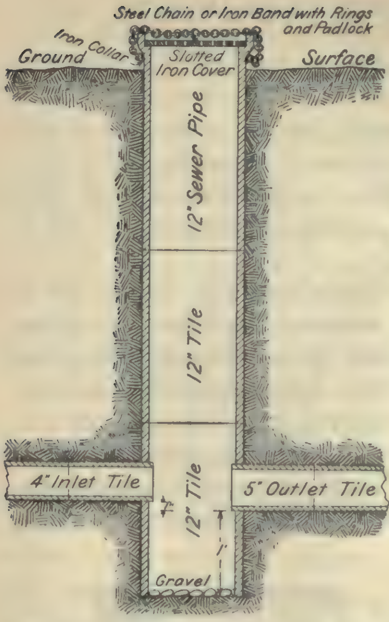

FIG. 15.—Observation well and sand trap constructed of tile.

length to accommodate the drain. Such a device is shown in figure 15. As may be seen, a small settling space is provided, from which sediment may be removed with a telephone spoon. A cover always should be provided and the joints should be cemented. This device costs little and occupies small space. If desired, the top section may be removed subsequently, a cap provided for the second section, and cultivation be carried on directly over the top. Such a device also may be installed for inspection purposes between regular manholes.

Surface inlets and flushing wells.—A vertical stack of tile or pipe is useful also as a surface inlet or flushing well. Figure 16 shows how it should be installed. The bottom should be paved with coarse gravel and the top provided with an iron grating and a mound of gravel or crushed stone. The backfill should be well compacted around the stack. Such an inlet should be installed wherever a drain crosses a depression or flat, so that the waste water or storm water may not pond long enough to puddle the soil or "burn" the crop. During irrigation the entrance of water may be prevented by throwing up a circular ridge of earth around the mound. One of these devices also should be used at the upper end of each branch line. The first few lengths of tile in the drain should be a size larger than the tile designed for the drain, so the water will not be retarded in its progress into the drain.

Flumes.—Flumes should be provided for all canals and ditches that cross under drains, and care should be taken to prevent large quantities of water from flowing across drains, particularly during the first few seasons after the installation of the system.

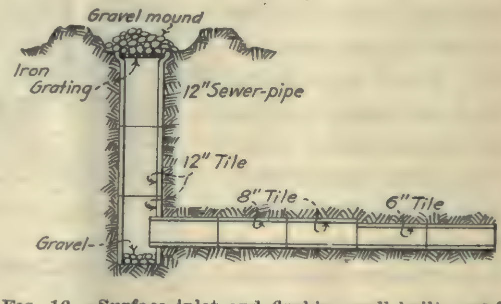

FIG. 16.—Surface inlet and flushing well built up of large tile and sewer pipe.

Relief wells.—The source of damaging water often is in some deep, pervious stratum, and the movement is upward. The stratum is connected with a higher lying source of supply, and the water is under pressure. Ordinary methods of drainage avail little since the damaging water rises between drains, however closely they may be spaced, and it is not unusual to find water standing on the ground surface within 10 feet of a drain 6 feet or more in depth. The source of the water may be in gravel, sand, stratified shale, sand rock, or lava. A pressure condition has been found even where the only change in subsoil conditions was in the nature of the clay strata.

To meet the condition it is necessary to install relief wells connecting the pervious stratum with a tile drain laid at ordinary depth. The pressure causes the water to rise through the relief wells which act as vertical drains. The sole purpose of the ordinary drain is to carry off the water brought up by the relief well, and it accomplishes little or no direct drainage. Figure 17 shows a relief well in the bottom of a trench. The tile had not been installed when the view was taken. With the pressure relieved at the drain level the damaging water no longer can make its way to the ground surface within the area affected by the well or system of wells. It is necessary in each case to determine the required number and spacing of the wells and the best indication is the effect of one well upon another.

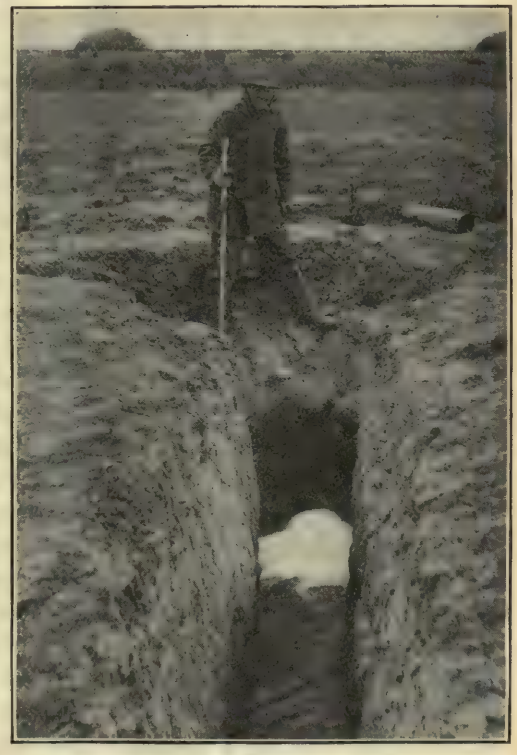

FIG. 17.—Relief well in bottom of drain trench.

An earth auger may be used for the installation of relief wells in ordinary soil, but in shale or rock it is necessary to use a well-drilling outfit. Often it is necessary to drill to a depth of from 20 to 50 feet. Usually relief wells must be cased. A vertical stack of tile or an iron pipe may be used for this purpose. Wooden tubes also have been employed. The casings should be connected carefully to the drain line so there will be no danger that they will silt up in periods of inactivity.

COSTS.

Owing to the great variety of conditions met in the drainage of irrigated lands, the cost of such work varies over a wide range. Chief among the many factors influencing cost are the size of the tract to be reclaimed, its relation to surrounding tracts, the degree of wetness, nature of the soil, type of drain installed, opportunity of obtaining an outlet, availability of materials, distance from factories and from railway connections, quality and cost of labor, feasibility of using machinery, season in which the work is done, knowledge of the man in charge, and method of handling the construction work.

Experience in practically all the Western States, under many different conditions, shows that the cost of draining ordinary-sized farms having an average soil that is neither so hard as to require picking nor so soft that serious caving of the banks of trenches will take place, ranges from $15 to $30 per acre with the average $20 per acre. If hardpan, rock, or shale be present, or if the soil be fluxible, the cost may run up to $50 per acre, or even more if much tight sheeting of the trenches is necessary. In a few special cases drainage of small tracts in the midst of unreclaimed lands has cost between $75 and $100 per acre, but these costs represent situations that would not be encountered in regular operations.

In regard to costs per unit of length of drain it may be said that clay tile at the factory ranges in cost from about 1 cent per inch of inside diameter per foot of length for the smaller sizes up to about 2 cents in the larger sizes. Hand trenching for tile up to 12 inches in diameter, under ordinary conditions, ranges in cost from 10 to 25 cents per linear foot for an average depth of 6 feet, with the cost increasing about 50 per cent for each additional foot, while trenching in hard or fluxible material will run up to more than 25 cents per foot for 6-foot trenching. Rock work would of course be much higher. When tight sheeting is required the work will cost 50 cents or more per linear foot. Machine trenching usually is cheaper than hand trenching, but few jobs have cost less than $1 per rod for ordinary soils and depths.

ALKALI RECLAMATION.

It has been stated that underdrainage is the basis of the reclamation of alkali or silt lands, and the fact has been pointed out that drainage alone often is ineffective for complete reclamation and that subsequent treatment is necessary. The salt content not only must be reduced to a safe percentage, but it may be found that the presence of the salts has injured the physical texture of the soil and perhaps destroyed the humus content. Humus must be restored, evaporation must be reduced so that the future rise of salts may be prevented, and the tilth of the soil must be improved.

If expedition be desired in the removal of salts, or if natural precipitation and irrigation are insufficient to effect a satisfactory reduction in the percentage, a good-sized stream of irrigation water should be turned on the land and allowed to percolate through the soil as rapidly as possible. This is best accomplished by diking the land into checks and ponding the water as deeply as feasible, each check having as large an area as the slope of the ground and the amount of available water will permit. In no case should an attempt be made to flush the salts from the surface. They must be leached out and carried downward in solution to the underground reservoir. The desirability of using large checks and liberal quantities of water is due to the fact that capillary attraction is equally effective in all directions, and it is necessary to offset the tendency of the salts to move laterally in the soil and reappear on a higher or dryer portion of the tract. For this reason it is required to make sure, in flooding, that all the surface is covered, even if knolls and ridges must be leveled first. It is advisable generally to cultivate a field thoroughly before the leaching process, but in some cases it has been found to be more satisfactory to flood first and then cultivate as soon afterward as possible. If the subsoil be so impervious that the leaching water does not percolate readily, it may be necessary to resort to subsoiling or blasting.

The following actual example of reclamation is offered to demonstrate the principles that have been stated:

Before drainage the ground water on a certain tract stood within 2 feet of the surface, which was covered with a white crust of alkali salts. Nothing of value grew on the tract, the only vegetation being an occasional salt weed. The average salt content for the first 4 feet of depth was 2.25 per cent of the soil. A drainage system was installed and in a month's time the excess water in the soil had run out, so that the ground water table was practically down to the level of the drains. This excess water contained a great deal of salt in solution, so that analyses made at the end of the month showed that the average salt content for the 4 feet had been reduced to approximately 1 per cent. The ground surface was cultivated and irrigated with a limited supply of water and some crops were planted, but gave only fair results. Meanwhile the higher temperature of summer had increased the evaporation and it was found that the average salt content for the 4 feet increased to 1.28 per cent in spite of the drainage. A nearby uncultivated and unirrigated spot which had been affected to some extent by the drainage system showed an average salt content for the first 4 feet of 1.51 per cent. It was evident that drainage alone would never reclaim the tract, so a heavy flooding was given it with the result that the average salt content for the first 4 feet was reduced to 0.43 per cent, which is less than one-fifth of the original content. At this time the nearby uncultivated spot showed an average salt content for the first 4 feet of 1.73 per cent, an increase which was due to the flooding of adjacent land while the spot itself remained dry. Further irrigation of the drained tract will reduce the salt content on the tract and increase that on the uncultivated spot. The results of this experiment are shown graphically in fig. 18.

Land should be cropped as soon as possible after reclamation; some crop which will shade the ground is preferable. If possible, the plants should be more or less alkali resistant. It must be kept in mind that the harmful salts are brought to the surface of the ground in solution by the capillary action of the soil and that they are deposited upon the surface when the solution is evaporated; hence the advisability of planting shading crops which reduce the evaporation. Artificial or soil mulches accomplish the same thing, and if shading crops are not planted, the soil should be kept well stirred. Subsoiling, in addition to assisting the leaching water to percolate to the drains, breaks up the capillary columns and retards the upward movement of salts.

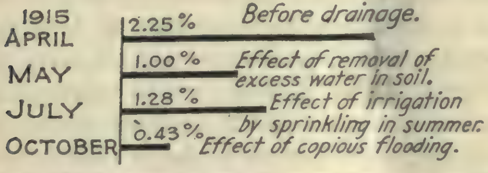

FIG. 18.—Diagram showing typical reclamation of alkali lands. Quantities are percentages of total salts in first 4 feet of soil.

Copious amounts of water should be used in irrigation and the water should be spread at once over as large areas as possible, making sure that the ground is covered as uniformly as may be. Waste water should not be allowed to run off the tract, as it is only the water that percolates downward that removes an appreciable amount of salt. However, water should not be allowed to pond in depressions or elsewhere for any considerable time after the head is turned off. If there is a tendency for the water to pond in this manner, either the depressions should be levelled up or surface inlets to the drain lines be provided, so that the excess may be removed in a short time.

Alfalfa and sugar beets are fairly resistant to the effects of alkali salts and shade the ground surface well. Alfalfa is a valuable crop anywhere in the irrigated section and sugar beets are being planted over a large portion of the West. Sweet clover, while not so valuable a crop, is very useful in reclamation work. All of these crops may be used in restoring humus to the soil. Grains do fairly well, barley being the most resistant, but they do not offer much shade or add greatly to the humus content of the soil when plowed under. For best results grain should be planted in the fall so that the plants may become sturdy before the salts become concentrated on and near the surface the following spring. It has been shown by Thomas H. Kearney[1] that the cane sorghums, and to a less degree the grain sorghums, are adapted to use on reclaimed lands.

MAINTENANCE.

If an under-drainage system be of proper design and construction the matter of maintenance is of small consequence. If silt has accumulated in the tile lines during construction they should be flushed out before the job is accepted. Irregularities due to the settling of the backfill should be corrected so that irrigation water will have no opportunity of making its way directly into a drain line. Vegetation that is likely to develop roots in the tile and obstruct the drains should be removed from the vicinity of the lines. Silt may continue to find its way into the tile lines for some time. This will be caught in the sand traps and should be removed from time to time.

In cases of serious obstruction of the tile by sediment or by the growth of roots, the conduit may be cleared with special cleaning devices, a number of which have been developed. These are very useful during construction in keeping the suspended matter in motion near the point of laying until sufficient water is developed to carry the material along. After the system is put in operation they may be used to clean out such roots as may have penetrated the tile line through the joints or to clear the line of obstructions caused by sand and silt. One of these devices is in the nature of an auger, while another is built like a small hoe. For the removal of roots an apparatus involving a spiral cutter is used, or, better still, a sort of wire brush. The latter is also useful in removing other obstructions and may be made easily by wrapping a piece of leather belting around a cylindrical wooden rod, first having driven the belting full of nails of such length that the outside diameter of the completed brush is somewhat smaller than the inside diameter of the tile to be cleaned. A still simpler device, and one that has proved very satisfactory, is a bunch of barbed wire. These devices may be operated most conveniently by means of jointed sewer rods. The latter are made up in 3 or 4 foot sections, fitted with couplings so arranged that they may be joined when two sections are placed at right angles, and are

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[1] Kearney, Thomas H. The Choice of Crops for Alkali Land. U. S. Dept. of Agriculture, Farmers' Bulletin 446, pp. 20–21.

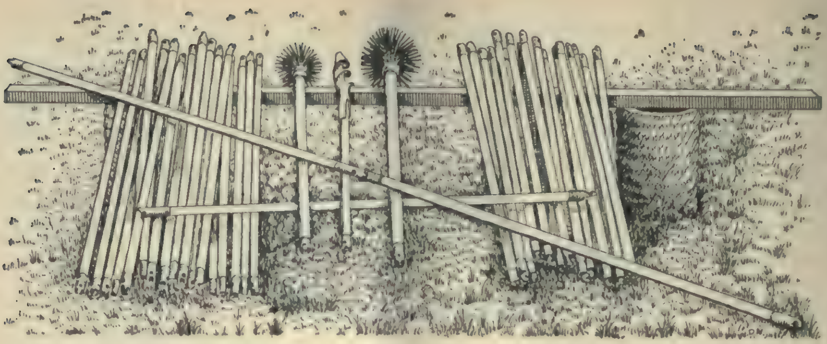

FIG. 19.—Sewer rods and tile-cleaning devices.

locked together when the two sections are in line. Working in a manhole 4 feet square, a man can easily put together and operate several hundred feet of rod in a tile line. Figure 19 shows a set of sewer rods and cleaning devices that have given satisfaction in operation.

The operation of drainage systems should be observed frequently by examination of the flow at the outlet and through manholes, observation wells, etc., and if any portion becomes inactive it should be looked after at once, for it should be remembered that the damaging alkali salts have not been removed entirely by drainage, and that a subsequent rise of the ground-water table certainly will be followed by a new accumulation of these harmful substances.

NECESSITY AND ADVANTAGES OF COOPERATION.

Frequently it is not feasible for one individual to drain alone, and it is almost never economical to do so. The unit cost of drainage decreases as the size of the tract increases. This is due partly to the fact that a system installed on a small tract receives water from without the boundaries of the tract and accomplishes more or less complete drainage over a considerable area. Furthermore, the unit cost of all materials and operations is less on the larger projects, and the required capacity of drains becomes relatively smaller as the unit becomes larger while the cost per unit of water carried is much less in the case of large tile than in the small. Economy demands that tracts as large as possible be handled as units, and where the land is owned by a number of persons it is necessary that some sort of cooperation be effected. Cooperation by mutual agreement usually is difficult and sometimes impossible to secure, owing to an unprogressive spirit among some of the landowners. Cooperation under an official organization is much more satisfactory and effective, and the legislatures of practically all the Western States have provided laws under which cooperative work may be done.

In general, these laws provide for the formation of drainage districts and for their government, prescribe their powers and privileges and outline the duties of their officers. The direction of the business of a drainage district is in the hands of a board of drainage supervisors who are appointed by the county commissioners or the district court, depending upon which is the recognized authority in the matter of formation of drainage districts. Drainage districts may exercise the right of eminent domain and bonds may be issued to pay for the construction work. The bonds are retired by assessments collected in the same way and as a part of the regular taxes against the property, so that the cost of reclamation is borne by the returns from the land and is not a direct burden on the landowners. The construction work should be done under the direction of a drainage engineer appointed by the board of supervisors.

The usual procedure is to present a petition to the court or board stating that the lands are in need of drainage and that the benefits of reclamation will exceed the sum of the damages caused and the cost of the work. Hearings are held after due notice has been given, and the district is organized as a legal institution. In most States the organization of such districts is effected so easily and the operation under the law is so simple that it is advisable to make use of this method in carrying out the work.

CONCLUSIONS.

The drainage of wet and alkaline lands in the irrigated section is entirely feasible and may be accomplished economically if properly done. Such drainage must be the basis for the reclamation of these lands. Tile drainage is recommended for farm practice. Thorough studies of subsurface conditions must be made before successful systems can be designed. The present demand for the products of the farm make it imperative that these lands be reclaimed.

○

STANDARD VARIETIES OF CHICKENS

I. THE AMERICAN CLASS

ROB R. SLOCUM

Of the Animal Husbandry Division

FARMERS' BULLETIN 806

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

Washington, D. C. April, 1917

THE American class includes the Plymouth Rock, Wyandotte, Java, Dominique, Rhode Island Red, and Buckeye.

The fowls of these breeds are commonly called general-purpose fowls, because they are not only good egg producers but their carcasses are also well suited for the table. They are therefore the breeds best suited for the general farm flock, and include some of the most popular and widely kept varieties of chickens. They are in good favor with the poultry packers on account of their table qualities.

All the American breeds lay brown-shelled eggs. They all have yellow skins and shanks free from feathers, which are desirable qualities for table fowl in this country.

In size they are intermediate between the smaller egg breeds, such as the Leghorns, and the larger meat breeds, such as the Brahmas. In temperament they are also intermediate, being less active than the egg breeds but more so than the meat breeds. They are fairly good foragers.

They mature earlier than the meat breeds, but not so quickly as the egg breeds.

They are sitters and make good mothers. Where they are kept, natural methods of incubation and brooding can therefore be used.

A general description of the different breeds and varieties of the American class is given in this bulletin.

STANDARD VARIETIES OF CHICKENS. I. THE AMERICAN CLASS.

CONTENTS.

Page.
The kind of chicken the farmer wants........ 3
Characteristics of the general-purpose breeds. 3
Breeds and varieties............................ 4
The Plymouth Rock...................... 5
The Wyandotte........................... 11
Breeds and varieties—Continued.
The Java.............................. 14
The Dominique.......................... 15
The Rhode Island Red.................. 17
The Buckeye............................ 18

PRACTICALLY every farm in the United States keeps chickens. In the majority of instances the flock of poultry is kept merely as a side line, to utilize material which otherwise would go to waste, and to furnish eggs and meat for the farmer's table. At many seasons of the year the flock will produce a large surplus over what is needed for the farmer's own use, and this when sold yields a considerable income, sometimes sufficient to pay for the groceries and wholly or in part to clothe the family.

THE KIND OF CHICKEN THE FARMER WANTS.

To meet these demands the farmer therefore desires a breed or variety of chickens which are not only good layers, but also have size enough to provide suitable carcasses for the table. The breeds which meet these two demands are commonly called the general-purpose breeds, and in the main are those comprising the American class as given in the American Standard of Perfection. The Orpington, belonging to the English class, is also a well-known general-purpose breed in this country. The general-purpose breeds are undoubtedly the most popular breeds in the United States. Certain of these, namely, the Plymouth Rocks, Wyandottes, Rhode Island Reds, and Orpingtons, compose the bulk of pure-bred poultry kept on the general farms, and their blood is evident in most of the farm flocks.

CHARACTERISTICS OF THE GENERAL-PURPOSE BREEDS.

In size the general-purpose breeds are intermediate between the meat breeds, such as the Brahmas, and the egg breeds, such as the Leghorns. They are of a much quieter temperament than the egg breeds, and for that reason are more easily handled in confinement. They mature earlier than the meat breeds, but not so quickly as the lighter egg breeds. In activity and ability to "rustle" for a living they are again intermediate between the meat and the egg breeds, but are good foragers. Because of the fact that they fatten readily and are of a fair size they are very popular with the poultry packer, and sell to better advantage in those localities where the farmer is compelled to look to the poultry packer for a market for his fowls.

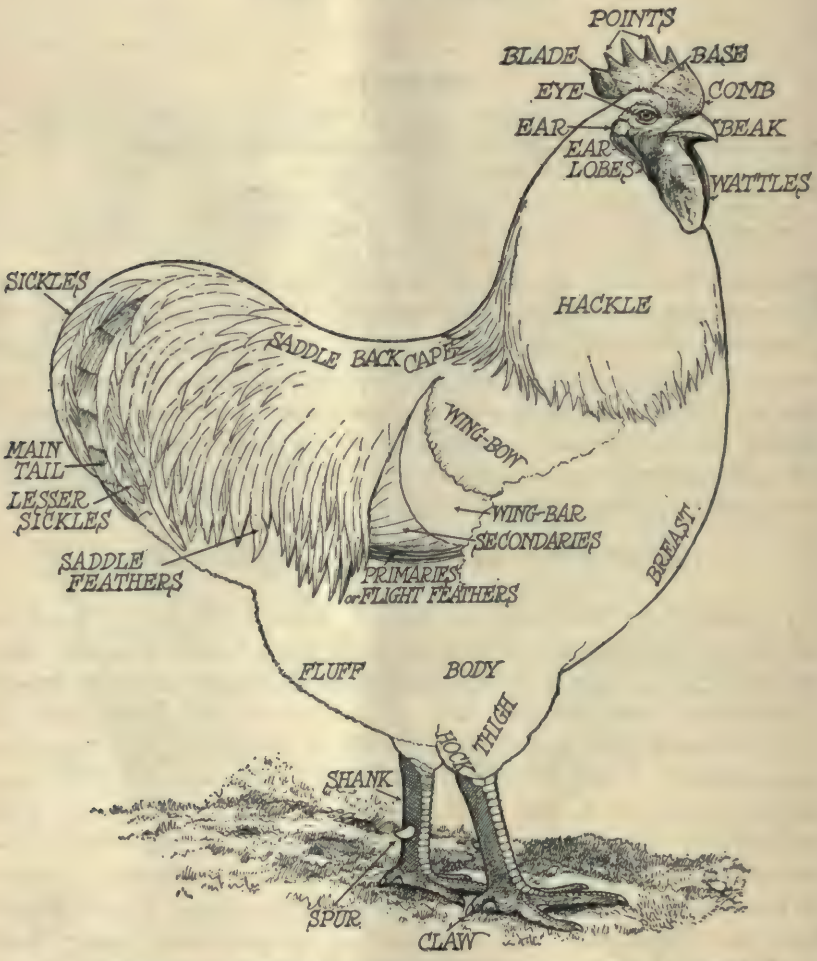

FIG. 1.—Glossary chart giving the names of the various sections of a male fowl.

Because of the tendency for the general-purpose breeds to put on fat much more readily than the egg breeds, they must be fed more carefully when kept in confinement, otherwise there is a tendency for them to "break down behind," in other words, to accumulate an excessive amount of fat in the abdominal region. Where the fowls have free range, however, this trouble is not likely to occur.

They are sitters and make good mothers. This is an important consideration where the farmer keeps only a small flock and does not wish to invest money in hatching and brooding equipment. All of these birds are layers of brown eggs. In consequence, they are not as suitable for conditions where a premium is paid for white eggs; under such conditions, where large poultry farms have been established, the White Leghorn has come to be the most popular fowl.

All the American breeds are clean legged; that is, they have shanks free from feathers. They also have yellow legs and skin, except the Java, in which the legs are black or leaden blue and yellow. In the markets of the United States the former is a desirable point, as the demand is for yellow skin and legs in table fowls.

BREEDS AND VARIETIES.

The American class includes the following standard breeds and varieties:

BREEDS.	VARIETIES.
Plymouth Rock	Barred, White, Buff, Silver Penciled, Partridge, Columbian.
Wyandotte	White, Buff, Silver, Golden, Partridge, Silver Penciled, Columbian, Black.
Java	Black, Mottled.
Dominique.	
Rhode Island Red	Single Comb, Rose Comb.
Buckeye.	

In describing these breeds and varieties it is the intention to give only a general statement of their appearance and characteristics. For a description sufficiently detailed to enable one to breed exhibition specimens it will be necessary to refer to the American Standard of Perfection, a book published by the American Poultry Association, which is the guide by which all the poultry shows in the United States are judged.

THE PLYMOUTH ROCK.

The Plymouth Rock has been for years the most popular breed in the United States. The Barred Plymouth Rock was the original variety and was developed in the United States, various lines of blood being used in the making. It is probable that the Dominique, the Black Cochin, the Black Java, the Brahma, and the Pit Game were used for this purpose. The size and type or shape of all the varieties of Plymouth Rocks are supposed to be identical. In general the breed may be described as a good-sized, rather long-bodied chicken, with fairly prominent breast and good depth of body, showing when dressed a well-rounded, compact carcass. This breed has a single comb and yellow legs, bill, and skin. The standard weight of cocks is 9½ pounds; of hens, 7½ pounds; cockerels, 8 pounds; pullets, 6 pounds. They are layers of good-sized, brown-shelled eggs, and are reputed especially as winter layers.

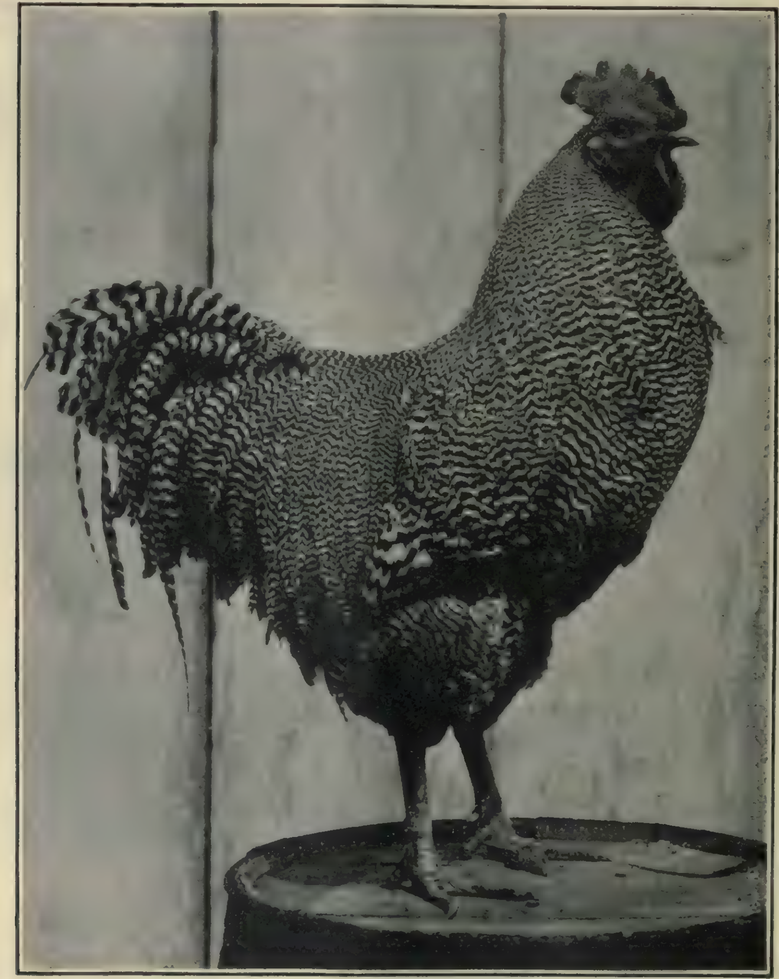

FIG. 2.—Exhibition or cockerel-bred Barred Plymouth Rock, male.

The Barred Plymouth Rock (figs. 2, 3, 4, and 5) is by far the most popular general-purpose or farm fowl. This variety has so long been a favorite with the general public that the barred color is generally associated with quality in table fowls. The Barred Plymouth Rock plumage is a grayish white, each feather of which is crossed by dark bars which are almost black. It is desired that these bars should be as even in width, as parallel, as straight, and as well carried down to the skin as possible. Each feather should end with a narrow, dark tip. The barring in the hackle and saddle is narrower than in other sections. The alternating dark and light bars give a bluish cast or shade to the general color, which should be even throughout the surface. It is common for solid black feathers or feathers which are partly black to occur in practically all strains in this variety, but this should not be taken as a sign of impure breeding. Black spots are also common occurrences on the shanks, particularly in females, but this does not indicate impurity.

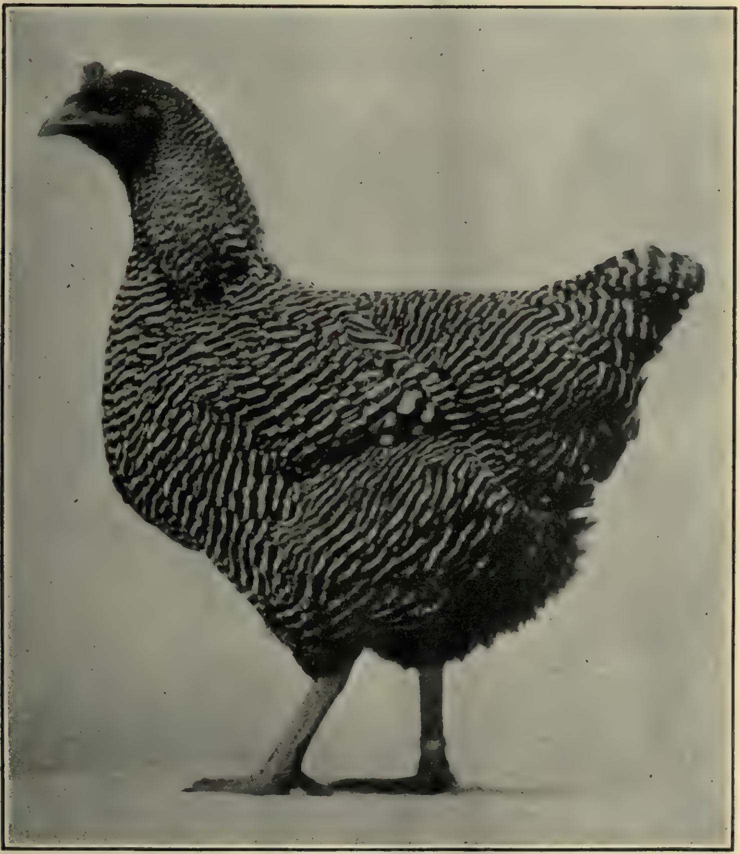

FIG. 3.—Cockerel-bred Barred Plymouth Rock, female.

There is a decided tendency for the males of this variety to come lighter in color than the females, and for this reason breeders are usually obliged to resort to two separate matings, one for the production of males of standard or exhibition color and the other for the production of females of standard or exhibition color. This system of breeding is known as double mating. In mating for males of exhibition color a male of about standard color is used with medium dark females, or those two or three shades darker than females of exhibition color, in which the barring is as distinct and as narrow as possible, showing a clear-cut line between the black and white bars. This mating is known as the cockerel mating, because it produces a greater percentage of exhibition or standard-colored males, while the females produced are too dark in color for exhibition, but are suitable for continuing this line of breeding. In mating for females of exhibition color, females of about standard color are used with a medium light male or one that is two or three shades lighter than males of exhibition color, but which shows distinct barring and as strong barring in the undercolor as can be obtained. This mating is known as the pullet mating, because it produces a greater percentage of females of exhibition color, while the males produced are too light for exhibition, but may be used to continue this line of breeding.

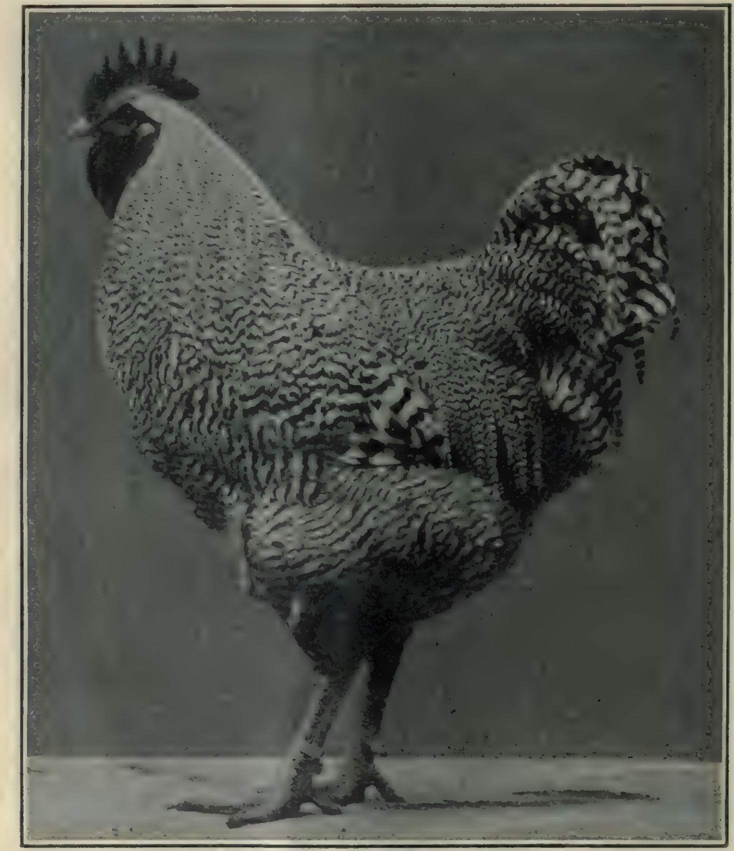

FIG. 4.—Pullet-bred Barred Plymouth Rock, male.

The White Plymouth Rock (see illustration on title page) is the second most popular variety of this breed. All the characteristics of the White Plymouth Rock are supposed to be identical with those of the Barred Plymouth Rock except color. As a matter of fact the White Plymouth Rock tends to run somewhat larger in size, and the type is a little more uniform and a little better than that of the Barred Plymouth Rock. In color the White Plymouth Rock should be a pure white throughout, free from black ticking and from any brassiness or creaminess.

The Buff Plymouth Rock is distinguished from the other Rocks by the color alone, which should be an even shade of golden buff throughout. Shafting, or the presence of feathers having a shaft of different color from the rest of the feather, and mealiness, or the presence of feathers sprinkled with lighter color as though powdered with meal, are undesirable. As deep an undercolor of buff as it is possible to obtain is desirable. There is a great difference of opinion as to what constitutes desirable buff color, some favoring the lighter color, approaching lemon, while others favor a much darker buff, approaching red. The important point is to have the shade as even as possible over the entire surface.

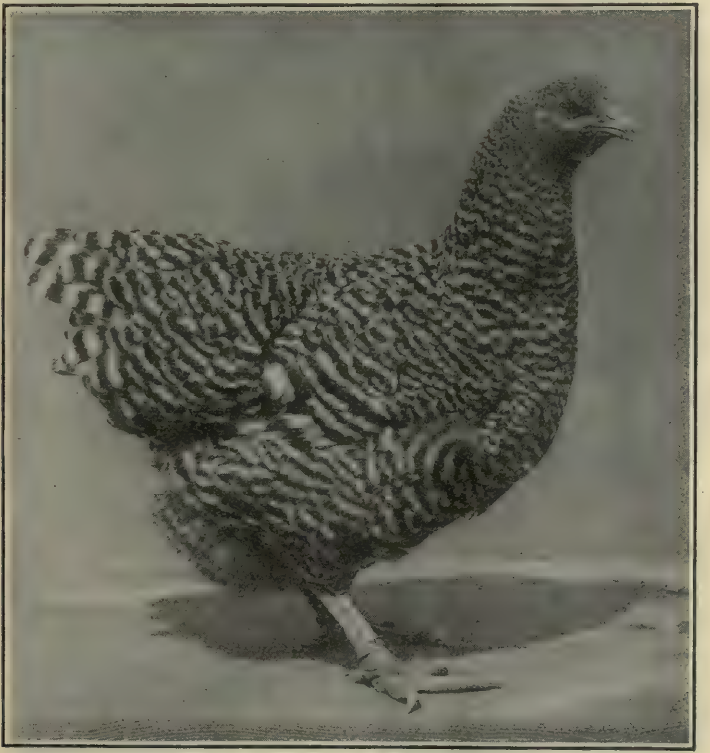

Fig. 5.—Exhibition or pullet-bred Barred Plymouth Rock, female.

The Silver Penciled Plymouth Rock is one of the new varieties. Its plumage is distinctive and very beautiful. In general, the plumage of the male consists of a silver white top color, extending over the shoulders and back, the hackle and saddle striped with black. The rest of the body plumage, including the main tail feathers and sickles, is black. The wings when folded show a bar of black extending across below the shoulder. Below this the wing shows white, due to the white on the outside of the secondaries. In the female the general trend of color is gray, with delicate, distinct, concentric penciling of dark on each feather except the hackle, each feather of which is silvery white with a black center, showing a slight gray penciling, and the main tail feathers, which are black, with the two top feathers showing some penciling. The color of the plumage is practically the same as that of the Dark Brahma.

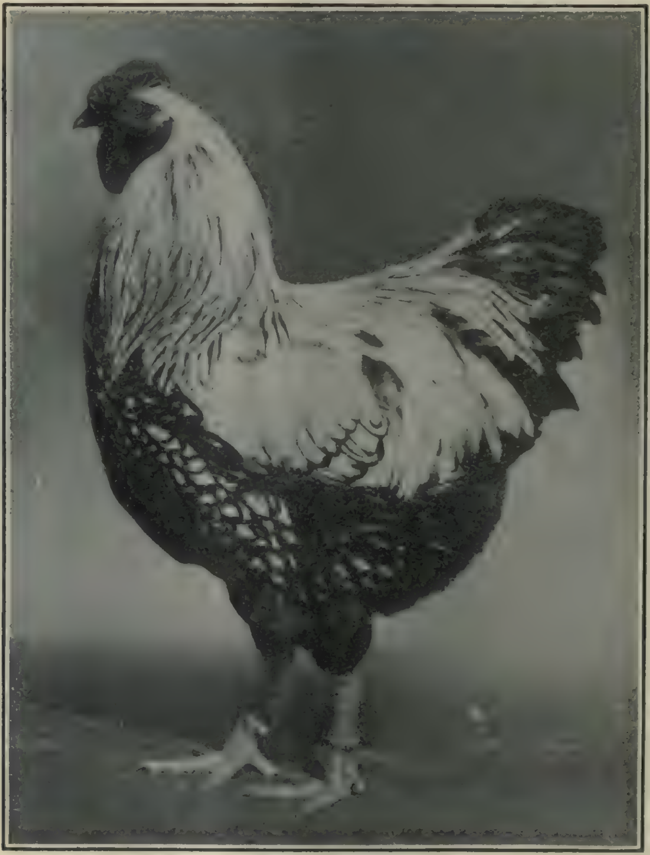

FIG. 6.—Silver Wyandotte, male.

The Partridge Plymouth Rock is also one of the newer varieties of this breed. The coloring of this variety is very attractive and is practically the same as that of the Partridge Cochin and also of the Silver Penciled Plymouth Rock, except that the white of the Silver Penciled is replaced by red or reddish brown.

The Columbian Plymouth Rock, a variety of comparatively recent origin, is very attractive in coloring and has proved quite popular. In general the color is white, the hackle feathers being black with a narrow edging of white, and the main tail feathers black, the tail coverts being black with a distinct white lacing. The wings also carry some black on the primary and secondary feathers, which is almost hidden when the wings are folded. The color of this variety is practically the same as that of the Light Brahma.

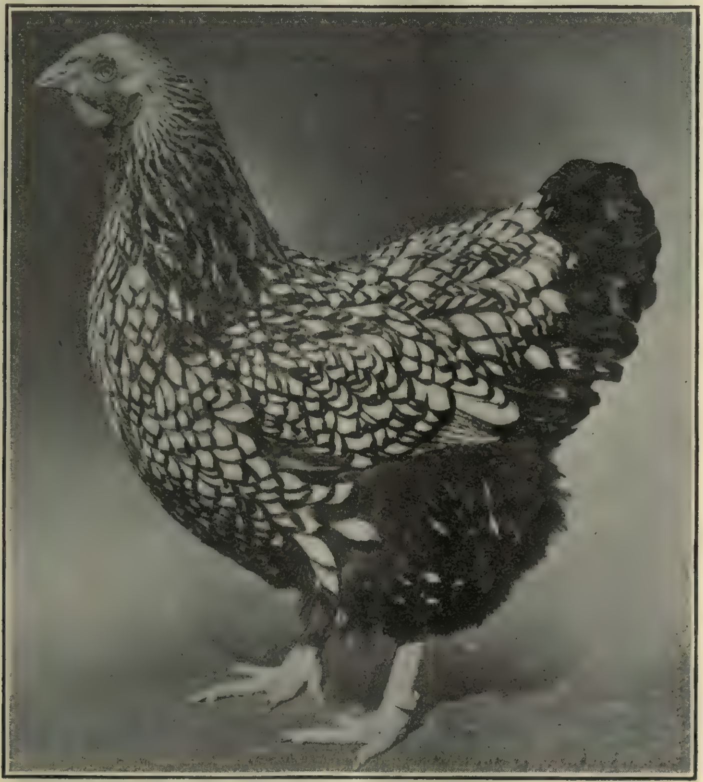

FIG. 7.—Silver Wyandotte, female.

THE WYANDOTTE.

The Wyandotte is a rose-comb breed and is characterized as a breed of curves. The body is comparatively round and set somewhat lower on the legs than the Plymouth Rock. It is inclined to be a looser feathered breed, and its general shape and character of feathering gives it an appearance of being somewhat short backed and short bodied. The Wyandotte is a breed which also was developed in the

United States, and has become very popular. The Silver Wyandotte was the original variety, and it is generally believed that the Dark Brahma, the Silver-Spangled Hamburg, and the Buff Cochin played a part in its origin. It is somewhat smaller than the Plymouth Rock, the standard weight being, for the cock, 8½ pounds; hen, 6½ pounds; cockerel, 7½ pounds; pullet, 5½ pounds. The hens are fairly prolific layers of brown eggs, are reputed to be good winter layers, and the breed as a whole makes a fine table fowl. The young chickens do not tend to have the same leggy stage which is characteristic of the Rocks and most of the other general-purpose breeds, and the breed is therefore well suited for the production of broilers. Like the Plymouth Rock, all the varieties of this breed are yellow legged and yellow skinned, which adds to their market popularity.

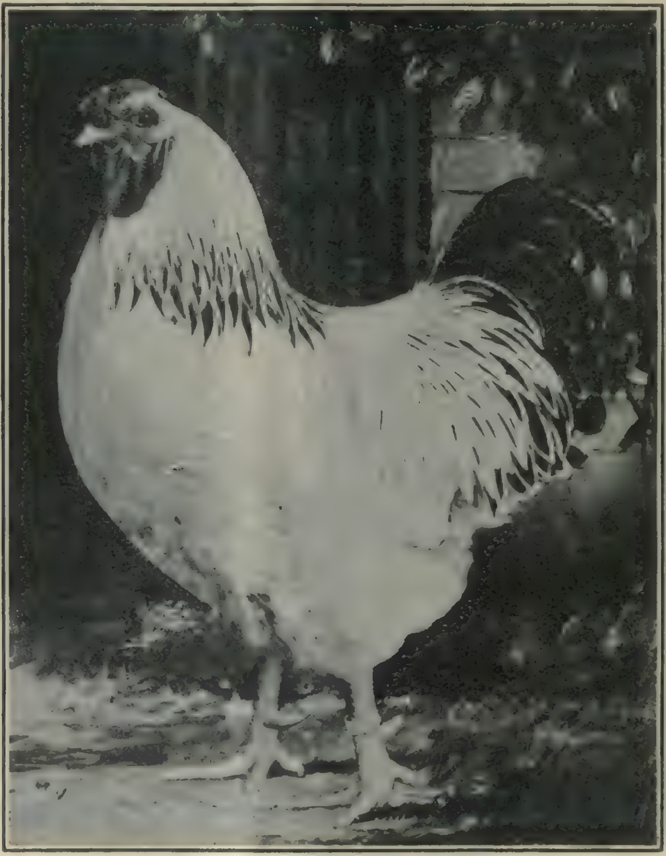

FIG. 8.—Columbian Wyandotte, male.

In the Silver Wyandotte (figs. 6 and 7) the male has a silver-white back and saddle, the hackle and saddle feathers being striped with black. The feathers of the body and breast are white, each laced with a black edge. The main tail feathers are black. The fluff is a slate color with some gray mixture. The color of the female shows white feathers laced with black over the entire body except the hackle, which is black laced with white, and the main tail feathers, which are black, and some black in the wings, while the fluff is slate mixed with gray. The color combination and the character of markings of the Silver Wyandotte make this a very attractive variety.

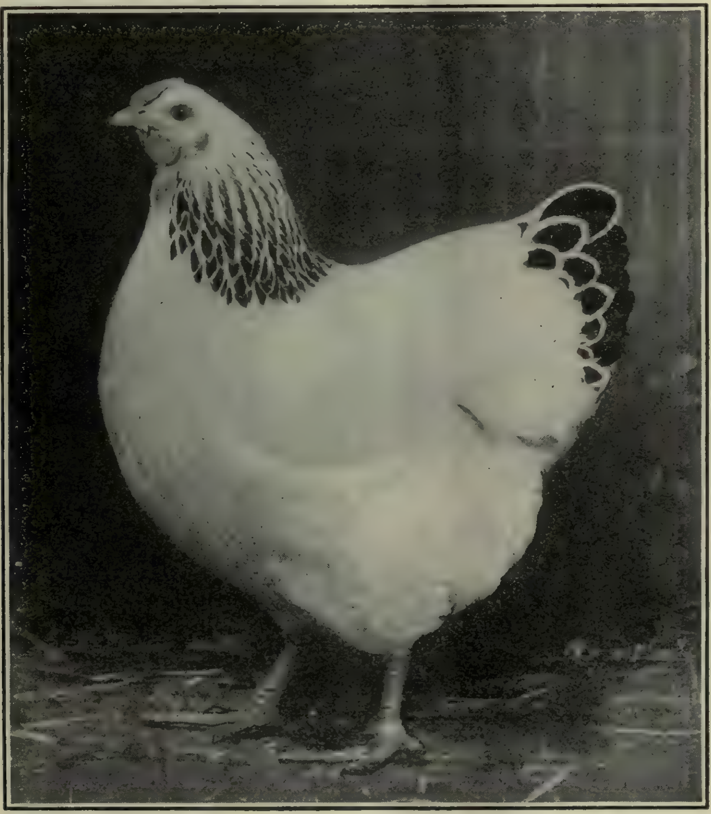

FIG. 9.—Columbian Wyandotte, female.

In the Golden Wyandotte the general color scheme is the same as in the Silver Wyandotte, except that the white of the Silver variety is replaced with red and reddish brown. Like the Silver Wyandotte, the color and markings of the Golden are very attractive.

The White Wyandotte is undoubtedly the most popular variety of this breed. The color is white throughout, and should be free from any brassiness or creaminess or black ticking.

In the Buff Wyandotte the color should be an even shade of buff throughout, being identical with that of the Buff Plymouth Rock.

In the Black Wyandotte the color is black in all sections, showing a greenish sheen, free from purple barring. The undercolor is lighter, somewhat on the slate order.

In the Partridge Wyandotte the color is the same as in the Partridge Plymouth Rock. In the Silver-Penciled and Columbian Wyandottes (figs. 8 and 9) the color is the same as in the corresponding varieties of the Plymouth Rocks.

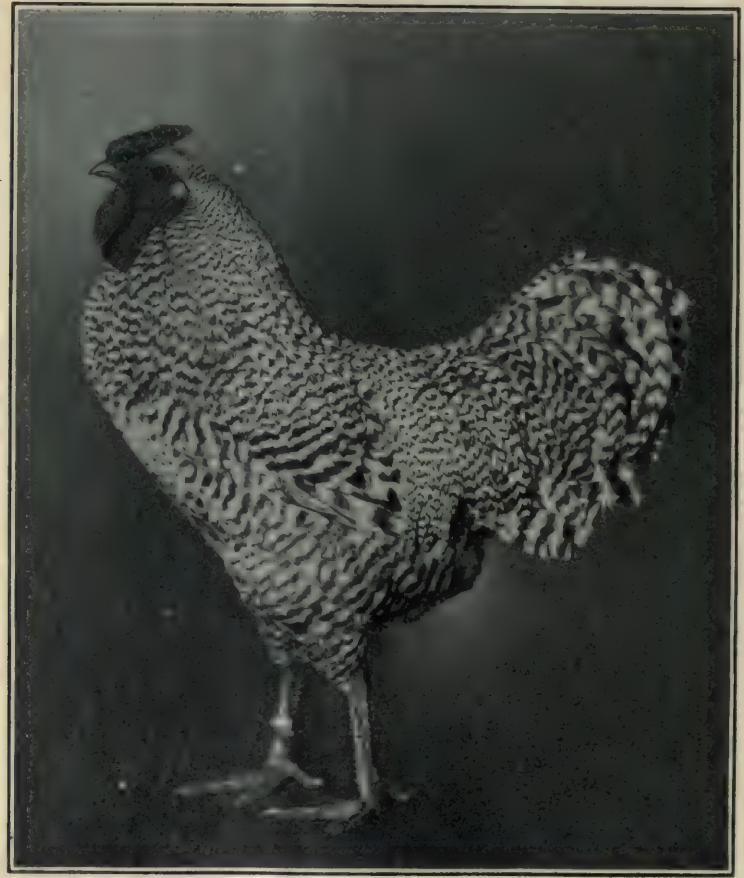

FIG. 10.—Dominique, male.

THE JAVA.

The Java is one of the oldest breeds developed in the United States. In general this fowl tends to be long in body and broad in back. The comb is single, and the legs of the Black variety are black, or black approaching yellow, while those of the Mottled variety are yellow and leaden blue. The color of the legs detracts somewhat from the fowl for market purposes. The skin, however, is yellow. The hens are good layers of brown-shelled eggs, and the fowls are suitable for table purposes. This breed is not very commonly found at the present time. The standard weights are: Cock, 9½ pounds; hen, 7½ pounds; cockerel, 8 pounds; pullet, 6½ pounds.

There are two varieties of Javas, the Black and the Mottled. The color of the Black Java is black throughout, with a greenish sheen on the surface plumage. Purple barring is undesirable. In the Mottled Java the plumage is a mottled black and white throughout, the black being more plentiful than the white. The undercolor of the Mottled Java is slaty.

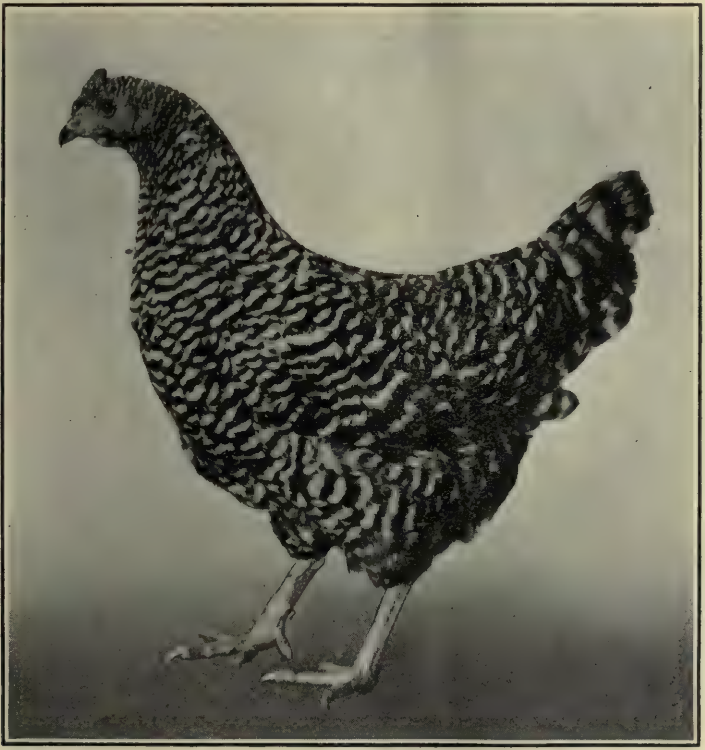

Fig. 11.—Dominique, female.

THE DOMINIQUE.

The Dominique (figs. 10 and 11) is also one of the oldest of the American breeds. The Dominique color is associated in the minds of people throughout the country with the barnyard fowl and is frequently confused with the Barred Plymouth Rock color. The Dominique is somewhat smaller and somewhat slighter in body, with a tail somewhat longer and sickles more prominent, than the other American breeds. This breed has a rose comb and yellow legs and skin. The hens lay brown-shelled eggs and are good table fowls, although somewhat smaller than the other general-purpose breeds. The standard weights for this breed are: Cock, 7 pounds; hen, 5 pounds; cockerel, 6 pounds; pullet, 4 pounds. The pure-bred Dominique is not extensively kept at the present time in the United States.

In color of plumage the Dominique has a general bluish or slaty cast, the feathers in all sections being barred throughout with alternate, rather irregular, dark and light bars. The markings somewhat resemble those of the Barred Plymouth Rock, but are less distinct, and lack the clean-cut character of the Plymouth Rock barring. Like the Barred Plymouth Rock, each feather should end with a dark tip. The Dominique male may be, and often is, one or two shades lighter than the female. Slate undercolor occurs throughout.

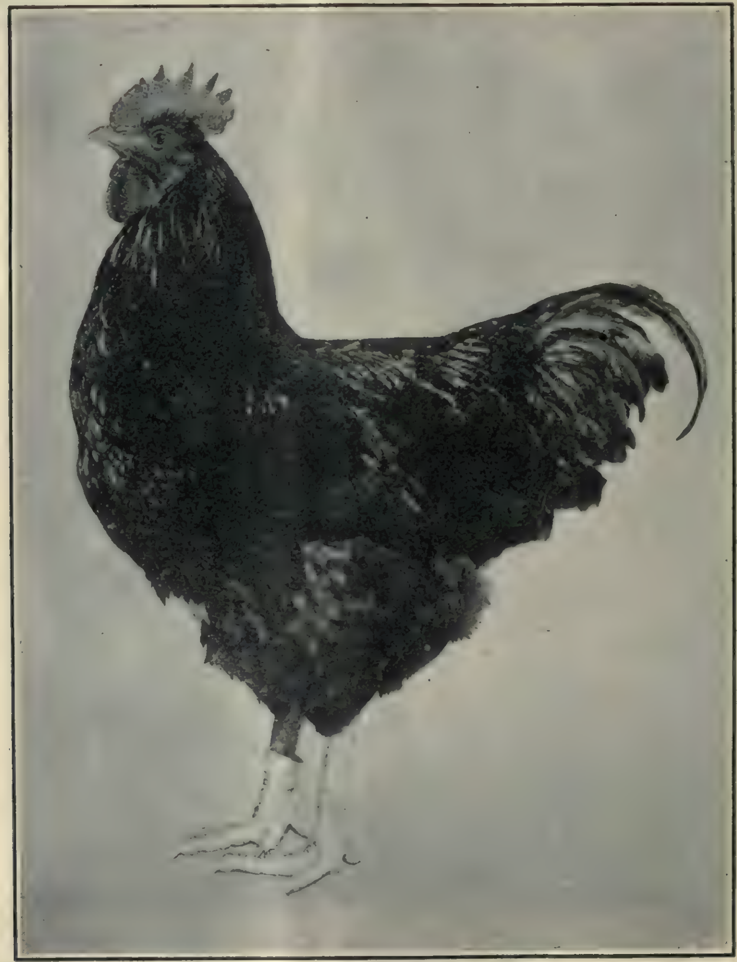

FIG. 12.—Single-comb Rhode Island Red, male.

THE RHODE ISLAND RED.

The Rhode Island Red (figs. 12 and 13) is one of the newer breeds which have been developed in this country. At the present time it bears an excellent reputation among the farmers and is kept very extensively throughout the farming districts. The breed originated in Rhode Island, where it was developed by the farmers engaged in poultry raising. The Malay, Buff Cochin, Buff Leghorn, and Wyandotte are said to have been used in its development.

In type the Rhode Island Red has a rather long, rectangular body and is somewhat rangier in appearance than the Plymouth Rock or the Wyandotte. The hens are prolific layers of brown-shelled eggs, and the breed makes a very suitable table fowl, having yellow legs and yellow skin. The Rhode Island Reds have enjoyed an excellent reputation for hardiness, which, in the main, they have well deserved. The standard weights for this breed are: Cock, 8½ pounds; hen, 6½ pounds; cockerel, 7½ pounds; pullet, 5 pounds.

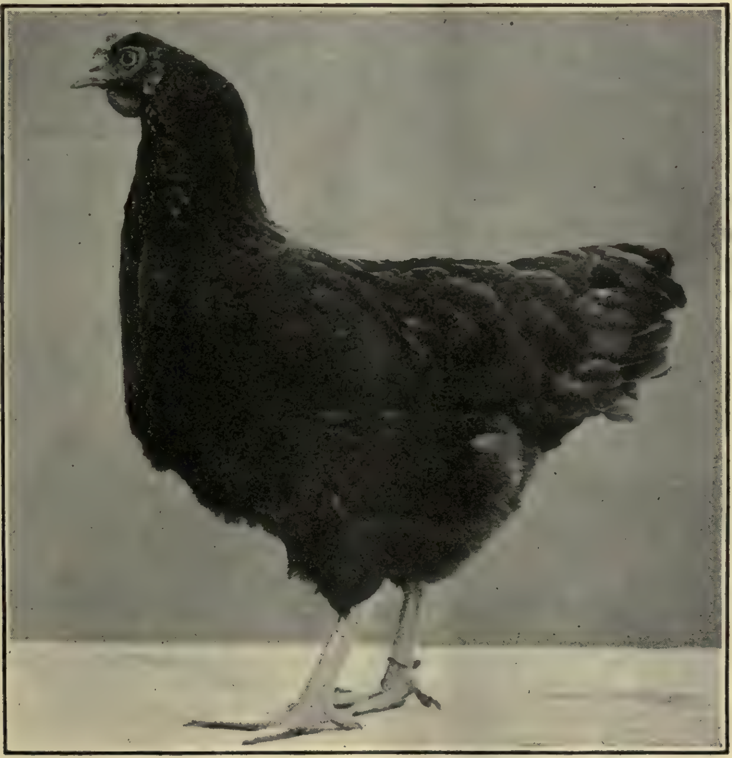

FIG. 13.—Rhode Island Red, female.

There are two varieties of the Rhode Island Red which are identical in color and type, but one of which has a single comb and the other a rose comb.

In color the Rhode Island Red is a rich, dark red, approaching a mahogany. It is desired to have this color as even as possible over the entire surface. There is a tendency, however, for the hackle and the lower part of the saddle of the male to be lighter in color than the back and shoulders. The main tail feathers in both sexes are black, and the wings also show some black. In the hackle of the female there is also a slight ticking of black. The undercolor of all sections should be red, and free from a dark or slaty appearance, which is known as smut.

THE BUCKEYE.

The Buckeyes are an American breed of comparatively recent origin. In type they approach somewhat to the Cornish, being erect and broad-breasted. The standard weights are: Cock, 9 pounds; hen, 6½ pounds; cockerel, 8 pounds; pullet, 5½ pounds. This breed has a pea comb, which doubtless comes from the Cornish blood used in originating it. The hens lay brown eggs. In color Buckeyes are mahogany bay, which is slightly darker on the wing bows of the males. The flight and tail feathers often carry black as well. The undercolor should be red, except in the back, where a bar of slate is desired.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO POULTRY RAISING AND EGG PRODUCTION.

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Poultry Management. (Farmers' Bulletin 287.)
Pheasant Raising. (Farmers' Bulletin 390.)
Marketing Eggs through the Creamery. (Farmers' Bulletin 445.)
Capons and Caponizing. (Farmers' Bulletin 452.)
Hints to Poultry Raisers. (Farmers' Bulletin 528.)
Important Poultry Diseases. (Farmers' Bulletin 530.)
Organization of Boys' and Girls' Poultry Clubs. (Farmers' Bulletin 562.)
Poultry House Construction. (Farmers' Bulletin 574.)
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Goose Raising. (Farmers' Bulletin 767.)
Turkey Raising. (Farmers' Bulletin 791.)
How to Kill and Bleed Poultry. (Bureau of Chemistry Circular 61, revised.)

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BREAD AND BREAD MAKING IN THE HOME

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FARMERS' BULLETIN 807

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the States Relations Service
A. C. TRUE, Director

Washington, D. C. April, 1917

THIS BULLETIN attempts to describe in simple terms the general principles on which bread making is based and suggests an easy standard method for making yeast-raised wheat bread in the ordinary household. It also indicates how this standard recipe may be modified to make different types of yeast-raised bread, and gives a few other recipes for breads made from other cereals than wheat or raised by other means than yeast.

BREAD AND BREAD MAKING IN THE HOME.[1]

CONTENTS.

	Page.
Importance of bread in the diet	3
Qualities of good bread	4
Principal requirements in bread making	5
Recipes for making bread	14
How to judge bread	23
Nutritive value of bread and its place in the diet	24

IMPORTANCE OF BREAD IN THE DIET.

The name "bread" is given to a very large number of foods, which differ considerably not only in appearance and taste but also in food value. In the United States wheat bread raised by means of yeast is most common, and whenever in this bulletin the word "bread" is used alone it may be taken to mean this kind. Other kinds are referred to by such terms as rice bread, rye bread, and self-rising bread.

Bread may be made out of wheat flour, water, yeast, and salt. Even when it contains no other ingredients than these, it has not always the same food value, pound for pound, for flours themselves differ in composition, and, moreover, some flours take up more water than others, the result being moister bread. Sometimes a little sugar or fat is added to the ingredients, and milk is often substituted for part of the water. These substances contribute somewhat to the nutritive value of the bread, but they are used in such small amounts that they are much less important than the flour. The food value of a pound of bread is, therefore, not far different from that of the flour used in making it.

The wheat flour used in making a pound of bread (about two-thirds of a pound, or 11 ounces) contains, in round numbers, half a pound of starch, which serves as fuel for the body; 1½ ounces of protein, which, in addition to serving as fuel, helps to build and repair the body machinery; and 1 ounce of water. The small portion that remains contains fat and sugar, which, like starch, serve chiefly as fuel; cellulose, in the case of whole-wheat bread, which gives needed bulk to the diet and tends to prevent constipation; mineral substances, which help to make bones and teeth and have a large number of other uses; and certain newly discovered substances which are present in very small amounts in many foods and are believed to have an important part to play in keeping people well.

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[1] Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.

NOTE.—This bulletin is of special interest to housekeepers.

The many substances present in bread, or, rather, in the flour out of which it is made, and the very many uses to which they may be put in the body suggest, at first thought, that wheat alone must be a complete food for supplying every need of the human body. This is not true, since the nutritive materials are not supplied in the right proportion. Nor are they in any of the other cereals—rye, corn, oats, rice, barley—which are often used in bread making. All cereals contain so much starch that if they are used in quantities sufficient to keep the body in repair and in good running order they overload it with fuel. Or, to put it in another way, if used only in quantities sufficient to supply the fuel needed, they do not provide enough body-building and body-regulating material. They come so near to being complete foods, however, that in almost every household they are the largest single item in the diet, and in many households they might, in case of need, be used even more largely than they are. This would be an advantage from the standpoint of economy, considering the nourishment that they supply in comparison with their cost.

In most households the products of cereal grains are served partly as breakfast foods, side dishes with meat, and desserts, but chiefly in the form of bread. The quality of the bread served is, therefore, a very important matter, and the different substances used in its preparation must be considered not only as foods but also with reference to the parts they play in the process of bread making.

QUALITIES OF GOOD BREAD.

Good bread is often described as porous or as containing a large number of holes or cells, all of which are of about the same size and shape. It is better for some reasons to think of it as a mass of tiny bubbles made out of flour and water and hardened or fixed in shape by means of heat. This calls attention not only to the size of holes or cells, but also to the character of walls of the cells which in good bread are always very thin.

A loaf of bread should be light in weight, considering its size, and should have a symmetrical form and an unbroken, golden-brown crust. The crust should be smooth on top and should have a certain luster, to which the term "bloom" has been given.

The loaf as a whole, the crust and the crumb, should be elastic. The loaf, if pressed out of shape, as it often is when slices are cut from it, should regain its form when the pressure is removed. Bits of the crust, if bent a little between the fingers, should show the same power to rebound, as should also the cut surface of the loaf if pressed.

The crumb should be creamy white in color and should have a "sheen," which may be compared with the bloom of the crust. This sheen can best be seen by looking across a slice rather than directly down into it. The distribution of the holes, on the other hand, and the thickness of the walls can best be examined by cutting a very thin slice and holding it up to the light.

The flavor of the bread should be, as nearly as possible, the flavor of wheat developed or brought out by the use of salt. This flavor is not easy to describe but is familiar to those who have tasted the wheat kernel.

PRINCIPAL REQUIREMENTS IN BREAD MAKING.

Many points should be kept in mind in making bread. These include (1) choice of materials, (2) choice of utensils, (3) cleanliness, (4) proportions of ingredients, (5) measuring, mixing, and molding, (6) care of dough while it is rising, (7) care of bread while it is baking, and (8) care of loaves after they are taken from the oven.

MATERIALS.

Necessary materials: Flour, water, salt, yeast.
Materials occasionally used: Milk, sugar, fat.

Flour.

The fact that wheat dough can be made light or changed into a mass of thin-walled bubbles is due to the presence in wheat of a proteid substance known as gluten. Flour, when mixed with water, forms an elastic mass; this is due to the gluten, the particles of which tend to cling together when the dough is pulled or when it is stretched by the formation of bubbles of gas within it. Glutens, however, are not all alike. Some are far more elastic than others and can be more easily stretched. Some, too, are stronger than others, and for that reason break less easily when stretched. Good bread flour, therefore, has not only the right amount but also the right kind of gluten. This depends partly on the kind of wheat from which the flour is made and partly on the way it is milled.

Durum wheat, which is particularly suited for growth in dry climates and is much used in the preparation of macaroni, has a large percentage of gluten. It is not, however, generally used for bread making, because the quality of the gluten is different from that of ordinary bread flour. In general, spring wheats, which are raised principally in climates where it is too cold for the wheat seeds to lie in the ground over winter, have more gluten than winter wheat, which is grown in milder climates. Both vary greatly, however, not only in the amount but also in the kind of gluten they contain. A "hard" winter-wheat flour may be as good for bread making as a spring-wheat flour.

The various parts of the wheat kernel differ more than the different kinds of wheat do. The outer coatings, often called "bran," are very rich in cellulose and in mineral substances, and are an important source of certain growth-regulating substances. The kernel, or the real seed, is divided into two parts—the germ, which is very small, and the endosperm, which forms about four-fifths of the entire weight of the seed and its coverings taken together. This endosperm contains all of the different kinds of nutrients present elsewhere in the berry—protein, mineral substances, and others—but, taken as a whole, it has a larger percentage of starch than any other part. The outer portion of the endosperm is, however, particularly rich in protein. It also contains coloring matter, and when included in flour gives to it a creamy white color.

In the old process of milling wheat all the parts of the berry were ground up together and the composition of the flour thus obtained was the same as that of the wheat from which it was made. If such flour was sifted in order to make a fine product, however, much of the bran was removed and with it much of the other nutritive material. Graham flour, made according to the original method recommended by Dr. Graham, was so finely ground that no sifting was necessary. This might have been truly called "whole-wheat flour." Small amounts of such flour may be prepared in the household by grinding wheat berries in a coffee mill or similar grinder and used in the preparation of breads. (See p. 18.)

In large, modern flour mills wheat is cleaned, tempered (i. e., moistened), and crushed between pairs of steel rollers. These pairs of rollers are adjustable much as the rubber rollers of a clothes wringer are. The wheat passes between a series of rollers, each pair being set closer than the pair before. As it does so the starchy portions which are in the center of the kernel break up first, because they are most brittle. These portions are sifted and the coarser parts returned to the mill. The same pressure that breaks the brittle parts flattens the bran, which has been toughened by tempering or moistening, and the germ, which, because it contains much fat, is oily rather than brittle. These parts can then be sifted out. By repeated grindings and siftings a white flour is finally obtained.

A good bread flour should be very fine, but when rubbed between the fingers should feel slightly granular, and if pressed in the palm of the hand should fall apart easily, neither remaining tightly packed nor showing the imprint of the fingers.

Some poor qualities in bread (mustiness, for example) generally are due to the way in which flour has been kept; others (thickness of the cell walls and lack of luster, for example) to the fact that the flour was a poor bread flour in the beginning.

Flour should always be kept in a cool, dry place, away from dust, flies, and vermin, and, since it absorbs flavors easily, away from other foods or other supplies which have strong odors. This applies equally to the home and to the store.

Mustiness in bread is believed to be due to a mold, which is likely to get either into the flour or on the bread itself. Ropiness in bread, a condition particularly likely to occur in hot weather, is due to a common bacillus. Molds and bacilli are living organisms which can generally be killed by the heat of cooking. When, therefore, flour or bread has become infected with either, the receptacle in which it has been kept should be scalded and dried or otherwise sterilized before a new supply of flour is put into it.

In buying bread flour it is best to have a reliable dealer recommend one or more brands and to try them carefully until a flour is found out of which good bread can be made by following the directions given here (p. 14) or in a reliable cookbook. If good bread can not be made out of a given flour by one method it often can by another. For instance, some flours are better suited for the short method of bread making, which is here called "the straight-dough process," and others for the "long sponge method." Some doughs are improved by being kneaded twice before they are made into loaves, and some are better if kneaded only once. All reasonable efforts should be made to suit the method to the kind of flour before the flour is condemned.

YEAST.

Yeast as we use it is made up of a very large number of tiny plants, each one of which is far too small to be seen with the naked eye. These plants have the power to grow and multiply in dough, feeding on the materials it contains. In growing they change sugar of the kind that is present in flour, and also ordinary sugar, into a gas and alcohol. It is believed, too, that they increase the amount of sugar in the dough by producing it from the starch. If these yeast plants are well distributed throughout a mass of dough many bubbles with thin walls will be formed. If they are not well distributed there are likely to be no bubbles in some places and large bubbles with thick walls in others.

Yeast plants when deprived of water and food stop multiplying. They may be kept alive, however, under these circumstances, and when water and food are again supplied to them they soon begin to increase in number and to act upon any sugar with which they come in contact. In a soft dough, or "sponge," they multiply rapidly at favorable temperatures. The purpose of the familiar process of setting a sponge, therefore, is to get a large number of yeast plants from a few.

Like all living bodies, yeast plants can be killed by heat; can be injured, if not killed, by extreme cold; and do their best work at certain temperatures. These temperatures, in the case of that variety of yeast commonly used in bread making, are between 75° and 90° Fahrenheit, the most favorable temperature being about 86°.

In practical bread making the fact must be kept in mind that dough, even if prepared by cleanly methods, always contains not only yeast plants but also bacteria, which are likely to make the bread sour or to spoil its flavor in some other way. Many of these bacteria are particularly active at the higher temperatures favorable for the yeast plant. For this reason as high a temperature as 86° should never be adopted, unless every process connected with bread making from sponge setting to the final rising in the pans can be pushed through without delay. In most households, where interruptions in bread making are almost unavoidable, a somewhat lower temperature (75° to 80°) is better, even when the bread is made by day and the dough can be watched. Even at these temperatures the entire process of bread making can be carried out in five hours, provided enough yeast is used. When the sponge or dough is to stand as long as overnight, a good temperature is 68° to 70°. Even then a temperature of 65° may be safer, provided it can be maintained and there is no danger of its falling below this point. At these lower temperatures yeast works slowly, to be sure, but so, too, do bacteria.

The kinds of yeast most commonly used are compressed, dry, and liquid yeast. The first-named is very convenient, for in this form the yeast plants are active and ready to begin their work. However, it is not easy to keep it long in good condition and so is commonly purchased fresh each time it is needed. When in good condition compressed yeast is soft and yet brittle and is the same color throughout, a creamy white. It should have no odor except that of yeast, which is familiar to most people but difficult to describe. Compressed yeast may now be obtained by parcel post either from manufacturers or from dealers. It is, therefore, no longer out of reach of those who are far from markets.

Dry yeast can be kept for a long time. It is, however, less active than compressed yeast, and for this reason is not convenient when the bread making must be hastened, but only in the long process or "sponge" method described on page 16. Dry yeast is often kept on hand, particularly by housekeepers who are not within easy reach of the markets, for use when other kinds of yeast are not readily obtainable.

Liquid yeast, like compressed yeast, is in active condition. It is easily made at home, and in a cool place can be kept for about two weeks. Its ingredients are water, yeast, and a substance which will serve as food for the yeast plants. This food is usually potato or hops. The following recipe, adapted from a State agricultural college publication,[1] will be found satisfactory.

LIQUID YEAST.

4 medium-sized potatoes, washed and pared.
1 quart hot water.
¼ cup sugar.
1 teaspoon salt.
1 cake dry yeast soaked in ¼ cup lukewarm water, or
1 cake compressed yeast.

Grate or grind the potatoes directly into the water (a food grinder is convenient for the purpose). Boil about five minutes, stirring constantly. Add the sugar and salt and allow the mixture to cool. When lukewarm add the yeast. Keep at ordinary room temperature (about 70°) for 24 hours, when it will be ready for use. This yeast should be kept in a cool, dark place. An earthen jar or enamel-ware pail is a good container for it and should be scalded before the yeast is put into it.

In making bread a small amount of dough may be saved for use in place of yeast at the next baking. The same care, however, must be taken with it as with liquid yeast; it must be kept covered and in a cool place.

MILK.

Whole or skim milk may be substituted for part or all of the water used in making bread. It should be scalded thoroughly before use. When the long or overnight process is followed, it is well not to use milk in the sponge, for it is likely to turn sour.

FAT.

Fat, if used, may be butter, lard, beef fat, cottonseed oil, or any other of the ordinary fats used in cooking. It should, however, be wholesome, of good quality, and in good condition. Bread is so little improved by the addition of fat that it is a mistake to run the slightest risk of injuring its flavor by using fat of questionable quality.

UTENSILS.

The necessary utensils are mixing bowl, measuring spoons, measuring cup (of standard size, holding about half a pint), mixing spoon or knife, and baking pans. (Fig. 1.) Utensils desirable under some circumstances, particularly when several loaves are to be made, are bread mixer for kneading, molding board, bread raiser, and bread rack.

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[1] Oreg. Agr. Col. Club Circ. 6 (1916).

MIXING BOWL AND BREAD MIXER.

One or two loaves of bread can be kneaded in the bowl in which they are mixed, which "saves dishes." If more loaves are to be made, a bread mixer may be used. Care should be taken, however, to use one of the right size for the amount of dough to be made. When a bread mixer is intended for use in making four loaves it is not reasonable to expect it to be convenient for use in making one loaf. Even when several loaves are made at a time, neither bread mixer nor board is absolutely necessary, for the dough can still be conveniently molded in the bowl if it is first divided into two or three portions.

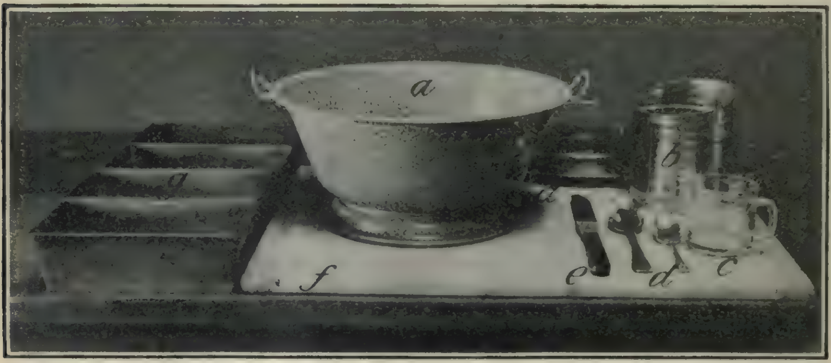

FIG. 1.—Utensils used in bread making: *a*, Bread pan and cover; *b*, flour sieve; *c*, measuring cup; *d*, large and small spoons; *e*, knife or spatula; *f*, bread board; *g*, baking pans.

BREAD RAISERS.

A bread raiser or bread cabinet where an even temperature can be kept is valuable in laboratory work. In the home, if available, it can be used for the dough or for the sponge and also, in cold weather, for bringing the flour to the desired temperature before it is made into dough.

A fireless cooker may be used in place of a cabinet for controlling the temperature of the dough while it is rising, or, in cold weather, dough may be placed in an ordinary unheated oven with some warm water near it in a stone crock or other receptacle in which water cools slowly. A teakettle is convenient for the purpose.

PANS.

Pans holding 1½ quarts are convenient because they are of the right size for a loaf made with 1 cupful of liquid. The loaves made in them have, too, a good proportion of crust and crumb. About 3 inches in height, 8 inches in length, and 3½ inches in breadth are good dimensions. If too low, the pans do not support the sides of the loaf properly and make it necessary to use a stiff dough. Some housekeepers use pans twice as wide as those mentioned, which hold two loaves, but, except for a slight saving of labor, these are less desirable, for the loaves are not of good shape, and each has one crustless side.

The material for the pans is of less importance than the size. It may be tin, sheet iron, aluminum, or heat-resistant glass. It is desirable, however, that all the pans used at one baking be of the same material, for heat passes through some materials more rapidly than through others. Seamless pans are easiest to keep clean.

BREAD RACK.

The bread rack consists of wire netting supported on short legs. On this bread can be cooled quickly. A substitute can be made easily at home by stretching wire netting over a wooden frame.

CLEANLINESS.

Everything connected with the process of bread making should be scrupulously clean. This is true of all forms of cookery, to be sure, but there is a special reason in the case of bread making. Dirt almost always contains bacteria, and these are likely to produce in dough substances which spoil the flavor of the bread. Yeast has no flavor which survives the cooking, and the substances which it produces, carbon dioxid and alcohol, are driven off by the heat of the oven. Bacteria, on the other hand, are likely to produce sour or rancid substances which are not removed by baking. All utensils, therefore, should be clean; the liquids should be scalded; the dry materials should be kept from the dust; liquid yeast should be kept cold and well covered; the hands should be washed and the nails cleaned before they touch the dough. Wooden toothpicks, which can be used for cleaning the nails and then thrown away, are a convenient part of the equipment for bread making.

MEASURING, MIXING, AND MOLDING.

In this bulletin it is recommended that for every loaf of bread there should be an allowance of 1 level teaspoonful of salt; 1 level tablespoonful of sugar, and 1 cupful of liquid, which should include any liquid there may be in the yeast. Butter or other fat, if used, should never exceed 1 level tablespoonful for a loaf. Yeast should be ⅛ of a cake of compressed yeast, or 2 tablespoonfuls of liquid yeast, if the overnight sponge method of making bread is followed, and ½ cake of compressed yeast or ¼ cupful of liquid yeast if the short "straight-dough" method is followed. If it is desirable to hasten the process, somewhat more yeast may be used. The amount of flour differs with every brand, but is always very close to 3 cupfuls or ¾ of a pound for each cupful of liquid. The required amount is sometimes more than 3 cups and in exceptional cases runs below 3 cups.

The water used should be as pure as for drinking purposes; if milk is used it should be scalded. The liquid is usually poured hot over the sugar, salt, and fat in the mixing bowl, though some housekeepers put in the salt and the fat later, because they tend to retard the action of the yeast. If the sponge method of bread making is followed, the yeast and about half of the flour (1½ cups for each cup of liquid) are added to the liquid as soon as it has become lukewarm. This sponge usually is made at night, kept at a temperature of 65° to 70° till morning, and then made into a stiff dough.

In the "straight-dough" or short-day process, all, instead of half, of the flour is added in the beginning. From this point, when a stiff dough is made, this process and the "sponge" process are carried through in exactly the same way.

In making stiff dough out of the sponge or out of the liquid containing yeast, the flour should be added gradually, and what is more important, the dough should be beaten thoroughly, or, when it gets too stiff for this, kneaded, after each addition of flour. If this is not done, too much flour is likely to be added and this spoils the texture of the bread. The time to stop putting in flour is when the dough can be kneaded without sticking either to the hands or to the board, even when they are unfloured. If for any reason more flour than this is added, the dough should be softened again by means of water or milk.

Dough is allowed to rise once, and sometimes twice, before it is made into loaves. If it is to be allowed to rise twice, the first kneading should be only sufficient to mix the ingredients, and the second should be continued 10 or 15 minutes. If the dough is allowed to rise only once, it should be kneaded for 10 or 15 minutes when it is first mixed. A second kneading is believed to improve the flavor and texture of the bread.

In making the dough, the first portions of flour may be mixed with the liquid by means of a flat knife or spoon. The knife has an advantage over the spoon because it is flexible and can be used for scraping the dough from the sides of the bowl. Kneading is simply another form of mixing, its purpose being to move one part of the dough over another and thus to bring new parts of flour and liquid into contact. It is better done with the balls of the hands than with the fingers, which often pierce the dough without accomplishing much in the way of mixing.

TEMPERATURE AND CARE OF THE RISING DOUGH.

Dough rises most rapidly at a temperature of about 86° F., and if it can be watched carefully, so that there is no loss of time at any point, this is the best temperature. Under most other circumstances a somewhat lower temperature, about 80° F., is better. It is easy to keep the right temperature if the dough is put into a bread raiser or a fireless cooker and a thermometer is used. Experienced housekeepers, to be sure, recognize quite well the right temperature for raising and baking bread by the sense of feeling, but uniform results are most easily obtained by the use of a thermometer. Inexperienced bread makers will do well to ask themselves whether they know the feeling of water or air at 80° or 86° F., and if they do not, to use a thermometer for a time at least. By doing this they can learn very quickly what experience alone would take a long time to teach.

Dough should be kept covered while it is rising, for otherwise a crust will form on top of it and interfere with the expansion. Some housekeepers brush the dough over with melted fat, but this is not necessary if the dough is well covered.

Beginners often have difficulty in telling whether the dough is ready to be divided into loaves and put into pans. A good rule is to measure its volume. When it is ready to be made into loaves, the dough for each loaf, if made out of hard-wheat flour, should amount to 3 pints; if made from soft flour, to about 2½ pints.

The levels to which these masses of dough will reach in the mixing bowl can easily be determined beforehand and marked. For illustration: If one loaf of bread is to be made, before mixing it pour 3 pints of water into the mixing bowl and mark the point to which the water comes. This will indicate the height to which the dough should rise.

When recipes direct that dough be allowed to double or treble in volume it is convenient to have a measuring glass to determine the expansion. An ordinary tumbler will do, but a glass of smaller diameter, like a small jelly glass, is better. Before the dough is set to rise tear off a small piece and pack it in the glass. Note the height to which it comes and mark the place it will reach when its volume has doubled or trebled, as the case may be. Put this beside the large loaves of bread and use it as an indicator.

SHAPING THE LOAVES.

When the dough has risen sufficiently, cut or tear it into the required number of loaves. Take each piece of dough in the hands and work it lightly in such a way as to stretch the underside, which is to become the top of the loaf. In forming the loaf, make no effort to fit it to the shape of the pan, for in rising it will fill out the corners. Strive merely to form it into an oblong piece with a smooth surface.

BAKING.

Loaves made with 1 cupful of liquid each should be baked 50 minutes. They should begin to brown in about 15 minutes. After that time the temperature of the oven should be lowered so that the loaves will bake slowly. The temperature should be 400° or 425° F. to begin with, should be increased to 425° F., and then dropped gradually to about 380° F. The surest way to get these temperatures is by means of an oven thermometer or an oven gauge. In the absence of these the following test may be made: Put into the oven a small piece of white paper, a white cracker, or half a level teaspoonful of flour spread in a layer ¼ or ⅛ inch thick on a tin plate. If it becomes a light golden brown in 5 minutes, the oven is about right in temperature to begin the baking.

If possible, pans should be so placed in the oven that the air will circulate around them. If they touch each other or the sides of the oven, the loaves will rise unevenly and be of unsightly shape. If the oven is crowded, it may be necessary to change the position of the pans occasionally to insure well-shaped loaves.

CARE OF BREAD AFTER BAKING.

The best way to care for bread after it is taken from the oven is to place the loaves, uncovered, on a bread rack or similar utensil, preferably where the wind will blow on them. Or the loaves may be placed across the edges of the empty bread pans in such a way that almost their entire surface is exposed. This method of caring for fresh bread, however, can be followed only in a place which is free from dust and flies; otherwise the bread must be covered.

The practice, common in the past, of wrapping warm bread in cloths to soften the crust, is losing favor because it is likely to spoil the flavor of the bread.

RECIPES FOR MAKING BREAD.

Directions for making wheat bread by several slightly different processes are given below. Under the first recipes, that for the short or straight process, the exact amounts for one, two, three, and four loaves are given, and these, with very slight changes, are the right amounts for use in the three recipes that follow after. The measurements have been given thus in detail for the convenience of the housekeeper. It is a comparatively easy matter to calculate the amount needed for several loaves from that needed for one, but in some cases different utensils are used in making large amounts. For example, sugar for four loaves is conveniently measured in a cup, while that for one loaf is measured with a tablespoon.

WHEAT BREAD.

Short or Staight-dough Process.

ONE LOAF.

1 cup lukewarm milk, water, or a mixture of the two.
½ cake compressed yeast.
or
¾ cup lukewarm milk, water, or a mixture of the two.
¼ cup liquid yeast.

1 teaspoon salt.
1 tablespoon sugar.
Fat, if used, 1 tablespoon, or less.
3 cups sifted flour.

Original bulk of dough, 1 pint; bulk when ready to be made into loaves, 2½ to 3 pints.

TWO LOAVES.

2 cups lukewarm milk, water, or a mixture of the two.
1 cake compressed yeast.
or
1½ cups lukewarm milk, water, or a mixture of the two.
½ cup liquid yeast.

2 teaspoons salt.
2 tablespoons sugar.
Fat, if used, 2 tablespoons, or less.
6 cups or 3 pints sifted flour.

Original bulk of dough, 1 quart; bulk when ready to be made into loaves, 2½ to 3 quarts.

THREE LOAVES.

3 cups lukewarm milk, water, or a mixture of the two.
1½ cakes compressed yeast.
or
2¼ cups lukewarm milk, water, or a mixture of the two.
¾ cup liquid yeast.

3 teaspoons salt.
3 tablespoons sugar.
Fat, if used, 3 tablespoons, or less.
9 cups or 4½ pints sifted flour.

Original bulk of dough, 3 pints; bulk when ready to be made into loaves, 3½ to 4½ quarts.

FOUR LOAVES.

1 quart lukewarm milk, water, or a mixture of the two.
2 cakes compressed yeast.
or
3 cups lukewarm milk, water, or a mixture of the two.
1 cup liquid yeast.

1½ tablespoons salt.
¼ cup sugar.
Fat, if used, ¼ cup, or less.
3 quarts sifted flour.

Original bulk of dough, 2 quarts; bulk when ready to be made into loaves, 5 to 6 quarts.

Boil the water or scald the milk. Put the sugar and salt (and fat, if used) into a mixing bowl. Pour the hot liquid over it and allow it to become lukewarm. Mix the yeast with a little of the lukewarm liquid and add it to the rest of the liquid. If convenient, set this aside in a warm place, not over 86° F., for one hour; if not convenient to set it aside, add the flour at once, putting in a little at a time and kneading until the dough is of such consistency that it sticks neither to the bowl nor to the hands. This requires about 10 minutes. Cover, and allow to rise 1¾ hours at a temperature of 86°; it may be better to set it at a lower temperature (see p. 13), but the lower the temperature the longer the time required for the rising. Cut down the dough from the sides of the bowl; grease the hands slightly. Knead a little and set aside to rise again for one hour. With a good bread flour, the dough would treble its bulk in each rising. With a soft wheat flour, it should not rise much beyond twice its volume. Divide into portions, mold, and place in greased pans of standard size (1½ quarts). Allow to rise until a light touch will make a slight dent. With good bread flour this happens when the dough reaches the top of the pans. Bake 50 minutes. (See directions for baking, p. 14.)

SHORT SPONGE METHOD.

Bread can be made during the day by what is known as the "short sponge" method. All the ingredients are the same as for the "short or straight-dough" process, but only half of the flour is added at first. When this mixture, which is called a "sponge," is so light that it will fall at the slightest touch, it is ready for the addition of the rest of the flour.

OVERNIGHT SPONGE METHOD.

Use the same proportions as for the short process, except in the case of the yeast, which should be one-eighth cake of compressed yeast or 2 tablespoonfuls of liquid yeast for each loaf. Use water rather than milk. In the evening mix the yeast with water, salt, and half of the flour, and beat thoroughly. Cover and place at a temperature of 65° to 70° F., or that of an ordinary room. In the morning add the sugar and the rest of the flour and proceed as in the case of the short process.

OVERNIGHT STRAIGHT-DOUGH METHOD.

Use the same ingredients as for the overnight sponge method, but put in all the ingredients at night.

RAISED BISCUIT.

Part of the dough prepared for wheat bread can be baked in the form of biscuits. Enough dough for one loaf, or that made from 1 cup of liquid, will make 24 small biscuits. Cut or pull small pieces from the dough and form them in the same way the loaves are formed. Hold the dough in one hand and shape it with the fingers of the other hand. The stroke should be light and from the outside inward, in order to stretch the bottom of the dough, which is to be the top of the biscuit. The biscuits may be placed either close together or some distance apart in the pan; in either case they should be rubbed over with melted butter. Allow them to treble their bulk and then bake them. The oven should be hotter than for baking bread, and they should begin to brown at the end of 5 minutes and should be done in 20 minutes.

PARKER HOUSE ROLLS.

2 cups milk.
3 tablespoons butter.
2 tablespoons sugar.
1 teaspoon salt.
1 cake compressed yeast.
Flour.

Put the butter, sugar, and salt in a mixing bowl. Scald the milk and pour it into the bowl. When it is lukewarm add the yeast, mixing it with a little of the liquid first. Add 3 cups of flour, beat thoroughly, cover, and let the dough rise until it doubles its bulk. Cut down the dough and add flour gradually until the mixture can be molded without sticking either to the hand or to the bowl. Let it rise again until about twice its original bulk and roll it on a floured board and cut it with a biscuit cutter. Brush the pieces over with fat, crease each piece through the center with a knife and fold it over. Let it rise again and bake in a hot oven about 15 minutes.

BAKING-POWDER BISCUIT.

2 cups pastry flour.
4 teaspoons baking powder.
1½ teaspoons salt.
2 tablespoons butter or other fat.
About ¾ cup milk, water, or a mixture of the two.

Mix and sift the dry ingredients. Work in the fat with a fork or with the fingers. Add the liquid gradually, making a dough that is of the right consistency to roll out easily. Turn out on a floured board and roll to one-half inch in thickness. Cut with a biscuit cutter, place in a buttered pan, and bake in a hot oven about 15 minutes.

An easier way is to add so much liquid that the biscuits can be dropped from a spoon on the baking tin. This saves the use of board and rolling pin.

Baking-powder biscuits and many other kinds of bread that are served hot contain more fat than ordinary wheat bread does and are usually eaten with more butter. These facts should be taken into consideration in planning meals, particularly those which are to be kept within a given fuel value.

MIXED WHEAT FLOUR BREADS.

The recipes given above for white bread can be followed in making bread out of part graham and part white flour. The usual proportions are either one part of graham to two parts of white, or half graham and half white. In all cases, however, white flour should be used for making the sponge. In place of the sugar an equal amount of molasses may be used. Such bread will not rise quite as much as bread made of white flour only.

WHOLE-WHEAT OR GRAHAM BREAD.

1½ cups lukewarm milk.
3 tablespoons brown sugar.
1¼ teaspoons salt.
3 cups whole-wheat or graham flour.
½ yeast cake.

Scald the milk, together with the sugar and salt. When lukewarm, add the yeast, mixing it first with a little of the milk. Add the flour, beat well, and let it double its volume. Beat it thoroughly, put into a pan, and let it rise. In a pan of standard size it should come nearly to the top.

The above recipe may be used in preparing bread from home-ground meal (see p. 6). There are many households, particularly in the country, where clean whole wheat can be obtained at moderate cost. If ground in the ordinary coffee mill, such wheat makes a coarse bread, not very light in texture, but of such good flavor that it may well be used occasionally to give variety to the diet. It is useful, too, in places where good bran can not be obtained easily and where coarse breads are desired as a means of preventing constipation.

In making such bread with a view to economy the housekeeper should compute what it will cost her per loaf, including labor and fuel, as compared with other breads she makes. Skim milk instead of whole milk can be used; homemade yeast, either liquid or dry cakes, is a possibility; and some might like the bread with less sugar or unsweetened. Another recipe which has been worked out follows:

HOME-GROUND WHEAT BREAD.

1¼ cups water or skim milk.
1¼ teaspoons salt.
1 tablespoon sugar.
3 cups home-ground wheat flour (for preparation see p. 6.)
½ cake dry yeast or 1 gill of liquid yeast.

Set a sponge at night, using half of the flour. In the morning add the rest of the flour, beat well, put into a greased pan, allow to rise until it doubles its bulk, and bake. (For particulars as to setting the sponge, etc., see directions for making wheat bread, p. 12.)

SELF-RISING BREAD.

This bread, which is commonly called by the misleading name of "salt-rising bread," has been known in one form or another for generations. It has been a particular favorite when and where it was difficult to get satisfactory yeast.

1 cup milk.
2 tablespoons white corn meal.
1 teaspoon salt.
1 tablespoon sugar.
Butter (if used), 1 tablespoon.
Flour.

Scald the milk. Allow it to cool until it is lukewarm; then add the salt, sugar, and corn meal. Place in a fruit can or a heavy crock or pitcher and surround by water at about 120° F. Water at this temperature is the hottest in which the hand can be held without inconvenience, and can be secured by mixing nearly equal parts of boiling water and tap water (unless the tap water is unusually warm). Allow the mixture to stand for 6 or 7 hours, or until it shows signs of fermentation. If it has fermented sufficiently, the gas can be heard as it escapes. This leaven contains enough liquid for one loaf. If more loaves are needed, add 1 cupful of water, 1 teaspoonful of salt, 1 tablespoonful of sugar, and 1 tablespoonful of butter for each additional loaf. Make a soft sponge by adding a cupful of flour for each loaf to be made. Beat thoroughly and put the sponge again at the temperature of about 120° F. When it is very light, add more flour gradually until the dough is so stiff that it can be kneaded without sticking to the hands or to the board. Knead 10 or 15 minutes, put at once into the pans, allow to rise until about two and one-half times its original bulk, and bake. Self-rising bread is never so light as the bread raised with yeast. A loaf made with one cupful of liquid therefore will come not quite up to the top of a pan of standard size.

POTATO BREAD.

The following recipes for potato bread have been so made as to use a large amount of potato as compared with flour. Excellent bread can be made with less potato. In making recipes it should be remembered that a pound of mashed potato contains about 1¼ cupfuls of water and starch and other substances about equivalent for the purpose to those in 1 cupful of wheat flour.

STRAIGHT-DOUGH METHOD.

FOUR 1-POUND LOAVES.

3 pounds boiled and peeled potatoes (equivalent to about 3¾ pounds water and 3 cups flour).
2¼ pounds bread flour.
1½ level tablespoons salt.
3 level tablespoons sugar.
2 cakes compressed yeast.
4 tablespoons water.

Clean thoroughly and boil, without paring, 12 potatoes of medium size, allowing them to become very soft. Pour off the water, peel and mash the potatoes while hot, being careful to leave no lumps. Take 3 pounds, or 5 solidly packed half-pint cupfuls of mashed potato, and when at the temperature of lukewarm water add to it the yeast, rubbed smooth with 3 tablespoonfuls of lukewarm water. Rinse the cup in which the yeast was mixed with another tablespoonful of water and add to the potato. Next add the salt, the sugar, and about 4 ounces of the flour, or 1 scant half pint of sifted flour. Mix thoroughly with the hand, but do not add any more water at this stage. Let this mixture rise until it has become very light, which should take about two hours if the sponge is at a temperature of about 86° F. To this well-risen sponge, which will now be found to be very soft, add the remainder of the flour, kneading thoroughly until a smooth and elastic dough has been formed. The dough must be very stiff, since the boiled potato contains a large amount of water, which causes the dough to soften as it ferments. Therefore add no more water to the dough unless it is absolutely necessary. Set back to rise until it has trebled in volume, which will require another hour or two. Divide the dough into four parts, mold them separately, and place in greased pans which have been warmed slightly. Allow the loaves to rise until they have doubled in volume and bake 45 minutes at a temperature of 400° to 425° F.

SPONGE METHOD.

FOUR 1-POUND LOAVES.

3 pounds boiled and peeled potatoes (equivalent to about 3¾ pounds water and 3 cups flour).
2¼ pounds bread flour.
1½ level tablespoons salt.
3 level tablespoons sugar.
1 cake compressed yeast.
4 tablespoons water.

Clean, boil, peel, and mash the potatoes as directed for the straight-dough method. In the evening take 1½ pounds, or 2½ solidly packed half-pint cupfuls, of the cool mashed potato, add to it the salt, 4 ounces of flour (or 1 scant half-pint cupful), and the yeast, rubbed smooth with water, reserving 1 spoonful to rinse the cup. In the morning add the remainder of the potato, the sugar, and the rest of the flour. Knead thoroughly until a smooth and very stiff dough is formed. Set away at 80° to 86° F. for about two hours, or until the dough has trebled in volume. Make into 4 loaves and proceed as in the straight-dough method.

POTATO ROLLS.

Very palatable rolls can be made from a similar mixture of boiled potatoes and flour by adding fat and sugar. The following proportions will yield about 1 dozen small rolls:

8 ounces boiled and peeled potatoes.
6 ounces or 1½ cups sifted flour.
⅓ cake compressed yeast.
¾ level teaspoon salt.
2 tablespoons lukewarm water, milk, or cream.
2 tablespoons sugar.
2 tablespoons butter.

Boil, peel, and mash the potatoes as directed for bread making. Add to this the salt, the yeast rubbed smooth and mixed with the water, or other liquid, and lastly 2 tablespoons flour. Set this mixture to rise at about 86° F. and allow it to rise till a touch will cause it to fall. Add to this sponge the butter, the sugar, and the remainder of the flour, and, if necessary, enough more flour to make a very stiff dough. Knead thoroughly until a smooth dough has been formed which is no longer sticky. Set back to rise again, and when the dough has trebled in volume knead lightly, form into small balls, and place, not too close together, in greased pans. Let rise until double in volume and bake 20 minutes in a moderately hot oven (about 400° F.).

CORN-MEAL-AND-WHEAT BREAD.

1½ cups milk, water, or a mixture of the two.
½ cake compressed yeast,
or
1¼ cups milk, water, or a mixture of the two.
¼ cup liquid yeast.
1½ teaspoons salt.
1 tablespoon sugar.
Butter (if used), 1 tablespoon.
1 cup corn meal.
2 cups wheat flour.

Pour 1¼ cupfuls of the water over the corn meal, salt, sugar, and fat (if used), and heat the mixture gradually to the boiling point or nearly to it and cook 20 minutes. This cooking can be done best in a double boiler. The water is sufficient only to soften the meal a little. Allow the meal to cool to about the temperature of the room and add the flour and yeast, mixed with the rest of the water, or the ¼ cupful of liquid yeast. Mold thoroughly, let rise until it doubles its bulk, make into a loaf, place in a pan of standard size, allow to rise until it nearly fills the pan, and bake 45 or 50 minutes.

RICE BREAD.

1 cup lukewarm water, milk, or a mixture of the two.
1 cup uncooked rice.
1¼ teaspoons salt.
1 tablespoon sugar.
Butter (if used), 1 tablespoon or less.
½ cake compressed yeast.
2 cups wheat flour.

Steam the rice with one-half of the liquid until it is soft. This is done better in a steamer than in a double boiler, for the liquid is so small in amount that the rice does not become soft readily and the presence of the steam helps. Put the sugar, salt, and fat (if used) into the mixing bowl and pour over them the remaining liquid (½ cupful). When the mixture has become lukewarm add the yeast and ½ cupful of flour. Allow this sponge to rise until very light. Add the boiled rice, which should have been cooled until lukewarm, and the rest of the flour. This dough is so thick that some pressure is required to work in the last portions of the flour. Allow the dough to rise until it has doubled its bulk, form into a loaf, place in a pan of standard size, allow it to rise until it nearly reaches the top of the pan, and bake.

RYE BREAD.

1 quart milk.
2 tablespoons sugar.
4 teaspoons salt.
2 tablespoons butter.
1 cake compressed yeast.
3 cups flour (1 cup being wheat and the remainder rye).

Follow the directions for making wheat bread according to the short process until after the bread has been molded the second time. At this point the dough should be placed in a 6-quart bowl lined with a cloth into which flour has been rubbed. When the dough has risen to the top of the bowl turn out on a hot sheet iron (a dripping pan inverted will do), over which 1 tablespoonful of flour has been sprinkled, and put it immediately into a very hot oven. After 10 minutes lower the temperature somewhat and bake for 1 hour. This recipe, which is used by permission of Mrs. Edith M. Thomas,[1] is a modification of an old German household method of making rye bread.

NUT BREAD.

1 egg.
1 cup milk.
½ cup sugar.
3 cups flour.
3 teaspoons baking powder.
1 teaspoon salt.
1 cup English walnut or pecan or hickory nut meats, cut into small pieces.

Sift together the flour, baking powder, salt, and sugar, and add the milk, the egg well beaten, and the nut meats. Place in a well-buttered pan and let rise one hour. Bake three-quarters of an hour in a moderate oven.

ROLLED-OATS BREAD.

2 cups boiling water.
½ cup brown sugar.
2 teaspoons salt.
1 yeast cake.
½ cup lukewarm water.
1½ cups rolled oats.
5 cups flour.

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[1] Mary at the Farm and Book of Recipes. By Edith M. Thomas. Norristown, Pa.: 1915, p. 171.

Dissolve the yeast cake in the lukewarm water. Pour the boiling water over the rolled oats, salt, and sugar, and let stand until lukewarm; add the dissolved yeast and flour. Let rise until very light, beat thoroughly, and turn into two buttered bread pans. When the loaves have doubled their volume bake them an hour in a moderate oven.

HOW TO JUDGE BREAD.

Expert bread makers and judges agree very closely upon the qualities of good bread, and the bread which they grade high suits the taste of the great majority of people. Even those who do not like it at first come in time to prefer it to the kinds of bread that are graded lower.

It is well for inexperienced housekeepers who wish to be good bread makers to have their bread judged once or twice by experts, because some qualities, which are difficult to describe in words can be demonstrated easily to the eye. Opportunities for this often are given at fairs, exhibitions, schools, etc. It is even more helpful, however, for beginners to learn how to judge their own bread skillfully, for by this means they are able to trace good or bad qualities to their causes quickly and thus to judge not only the bread itself but also the methods that have been followed in making it. (Fig. 2.)

FIG. 2.—Good bread is a very important part of the diet. Housekeepers should learn to judge and score their bread. See score card on page 24.

There are many good score cards for bread judging. They differ somewhat in detail, to be sure, but a loaf of bread judged by one of them usually will receive about the same mark that it would if judged by any of the others. The score card used in the Bureau of Chemistry, United States Department of Agriculture, for ordinary yeast raised white bread, is as follows:

Judging the quality of bread—A bread score card.

		Points.
1. General appearance	Shape	5
	Smoothness of crust	5
	Depth and evenness of color	5
2. Lightness		10
3. Crust	Thickness	5
	Quality (crispness and elasticity)	5
4. Crumb	Color	10
	Texture (size and uniformity of cells, thinness of cell walls)	15
	Elasticity (softness and springiness)	15
5. Flavor (taste and odor)		25
Total		100

NUTRITIVE VALUE OF BREAD AND ITS PLACE IN THE DIET.

Setting aside convenience, cost, and other such matters, it makes no difference whether the nutritive material of cereals is contributed to the diet in the form of bread or breakfast cereals, side dishes with meat, or desserts. In any case they may be used to the extent of nearly a pound a day in the diet of a man at moderate muscular work and to the extent of about 3 pounds a day in the diet of the typical family—father, mother, and three children between babyhood and adolescence. This would be equal to more than a pound of bread in the case of the man and 4½ pounds in the case of the family. Even if used to this extent cereals would not necessarily crowd out other foods—meats, eggs, milk, fruits, vegetables, butter, sugar, etc., needed to complete the ration or to make it taste good.

The amount of protein in breads and other cereal foods is too low as compared with fuel to make them perfectly balanced foods. The protein may be increased somewhat by the use of milk instead of water. The milk used in making a loaf of bread, even if it is skimmed milk, adds as much protein as there is contained in one egg, about one-third of an ounce of sugar, and a considerable amount of mineral matter. There is no object, however, in using milk for this purpose if it costs more than the same amount of food in some other form, or if the milk itself can be more attractively served in some other way.

Those substances which serve only as fuel are represented in wheat chiefly by the starch, though there is a little fat and often a little sugar. Experience has shown a very general preference for eating bread with butter or other fat material. This increases its fuel value and serves to lessen the proportion of body-building material. In the same way the use of fat in the preparation of breads or biscuits tends to decrease the amount of body-building material in proportion to fuel. A given weight, therefore, of bread and butter, or of bread containing a considerable amount of fat requires more protein-rich food (flesh foods, eggs, milk, cheese, or the like) to "balance it" than the same weight of plain bread does. These facts should be kept in mind in planning meals.

So far as mineral matter is concerned, bread is particularly rich in phosphorus. It should be supplemented, however, by something which contains more lime and iron, especially in the case of children. Milk provides the lime, and fresh fruits and vegetables the iron. If the latter are served in reasonable abundance, the kind of bread used is not a matter of great importance. If, on the other hand, fresh fruits and vegetables can not be obtained, it is considered desirable to use whole-grain flour in order to bring up the amount of mineral matters and of cellulose and to be sure of a sufficient supply of certain important growth-regulating substances.

The use of flours which contain more or less of the bran is often recommended on the ground that they are better sources of protein, mineral substances, cellulose, and growth stimulating or regulatory substances. It is true that they have more of these substances as compared with starch than white flours have. Side by side with this fact, however, should be considered the fact that they are not quite so thoroughly assimilated as white flours, or, in other words, a larger amount of them escape digestion. This offsets any advantage which they have over white flours as sources of protein, but not, according to recent theories of nutrition, as sources of mineral substances and growth-regulating substances. When, therefore, these flours can be obtained at the same or nearly the same price as white flours they merit consideration as sources of mineral and growth-regulating substances in comparison with milk, fruits, vegetables, and others. Even if one thus replaces some milk, fruit, and vegetables, it is not wise to omit them entirely.

To sum up, bread is the largest single item in the diet of the great majority of people. It should not, however, be the only item and, if it is to be rounded out into a satisfying ration, it must be accompanied by reasonable quantities of fruits and vegetables and of foods richer than it is itself in protein, in fat, and in sugar. In the case of little children, the protein-rich food should be milk. It is probable that if bread were uniformly well made it would be used in even larger quantities than at present, and this from the standpoint of economy would be a great advantage.

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Corn Meal as a Food and Ways of Using It. (Farmers' Bulletin 565.)
School Lunches. (Farmers' Bulletin 712.)
Food for Young Children. (Farmers' Bulletin 717.)
How to Select Foods.—I, What the Body Needs. (Farmers' Bulletin 808.)
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HOW TO SELECT FOODS

I. WHAT THE BODY NEEDS

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FARMERS' BULLETIN 808
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the States Relations Service
A. C. TRUE, Director

Washington, D. C. March, 1917

THIS BULLETIN does not attempt to make definite suggestions for obtaining food at low cost or to recommend any special foods or combinations of foods. It tells very simply what the body needs to obtain from its food for building its tissues, keeping it in good working order, and providing it with fuel or energy for its muscular work. It shows in a general way how the different food materials meet these needs and groups them according to their uses in the body. It suggests that, by remembering these groups and having them all suitably represented in the daily diet, the housekeeper can easily plan attractive meals which meet the needs of her family without waste of money or material.

HOW TO SELECT FOODS.[1]

I. WHAT THE BODY NEEDS.

CONTENTS.

	Page.
Purpose of this bulletin	3
The day's food	4
What the day's food should provide	7
Grouping foods to show their uses	8
How to tell whether or not the diet is adequate	11
General suggestions	13

PURPOSE OF THIS BULLETIN.

How can the housekeeper tell whether or not she is providing the food which her family needs and is getting the best possible returns for the money she spends? Unfortunately, the price she pays for food is no test of the nourishment it yields to the body. Tomatoes at 5 or 10 cents apiece in winter do not build body tissues nor furnish fuel for the body engine any better than those at 5 cents a quart in summer, nor does fancy capon at 40 cents a pound nourish the healthy body more generously than fowl at half the price. Appetite is not always a safe guide. A child's appetite might be satisfied with a diet of nothing but sugar, but this certainly would not be good for him. Neither can hunger and its satisfaction always be relied on. A bulky diet of potatoes or bananas alone would soon make a person feel that he had eaten enough, but would not furnish all that the body needs.

Evidently what a person who plans meals ought to know is what things the body needs in its food and how these needs can be filled by the ordinary food materials. This paper is intended to give such information in a simple way. It should make plain that different kinds or classes of foods serve different uses in the body and should help the housekeeper to choose those which will serve all these uses without waste.

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[1] Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.

NOTE.—This bulletin gives a simple method of selecting and combining food materials to provide an adequate, attractive, and economical diet.

THE DAY'S FOOD.

A man who does fairly hard muscular work would be likely to get the food which his body needs if supplied daily with such a combination of foods as the following:

1¼ pounds of bread, having about the same food value as 1 pound of such cereal preparations as wheat or rye flour, oatmeal, cornmeal, rice, etc.

2 ounces, or ¼ cup, of butter, oil, meat drippings, or other fat.

2 ounces, or ¼ cup, of sugar; or ⅓ cup of honey, or sirup, or an equivalent amount of other sweet.

1¼ pounds of food from the following: Fresh fruits and green or root vegtables.

12 ounces of food from a class which may be called "meats and meat substitutes"; that is, moderately fat meats, poultry, fish, eggs, cheese, dried legumes (beans, peas, lentils, cowpeas, and peanuts). Milk also belongs among these foods, but because of the large amount of water it contains half a glass, or 4 ounces, of it would be required to equal an ounce of any one of the others.

A man who works hard out of doors all day probably would need more food than this, and one who sits all day at his desk would need less. The amounts given are suitable for a man who, like a salesman in a store, walks about more or less and does more or less of such work as lifting.

A family consisting of a man and a woman who do moderately hard muscular work and three children—say, between 3 and 12 years of age—would get the food they require if supplied daily with:

4½ pounds of bread, having the same food value as 3 pounds of wheat or rye flour, oatmeal,, cornmeal or hominy, or rice; or about 2¼ pounds of cereals and 5 or 6 medium-sized potatoes.

¾ cup of fat (butter or butter with oil, beef drippings, or other fat)—a weekly allowance of 2½ to 3 pounds.

A little more than 1 cup of sugar, or a weekly allowance of 4 pounds; or an equivalent amount of some other sweet.

4 pounds in all of fresh fruits and fresh or root vegetables.

One of the two following, the choice depending on the age of the children:

3 quarts of milk and 1 pound of other foods taken from the meat and meat-substitute group.

2 quarts of milk and 1½ pounds of other foods taken from the meat and meat-substitute group.

This rather rough calculation is based on the assumption that cereals contain, on the average, about 12 per cent protein (see p. 7, B), 1 per cent fat, and 75 per cent carbohydrates, and that 1 pound of bread contains about ⅔ of a pound of cereal; that butter, oil, lard, and other fatty foods average 90 per cent fat; that fresh fruits and fresh and root vegetables average about ½ per cent protein and 10 per cent carbohydrates, with negligible quantities of fat; and that meats, fish, eggs, cheese, etc., as purchased, may be considered to average about 14 per cent each of protein and fat. The estimate also assumes that all the fat obtained with the meats, etc., is utilized, being either eaten with the meat or saved for use in cookery. Under these conditions the fuel value of the diet would be about 10,000 calories per family per day, or the equivalent amount of 3,000 calories per man per day; the protein value would be about 330 grams per family, or 100 grams per man per day.

Figure 1 represents the materials in such a ration. The cereals include 1½ pounds of bread, one ordinary-sized portion of rolled oats (one-fourth pound in all), and one of rice for each person (one-half pound in all), and a pound of flour for use in cooking. The meat and meat-substitute group includes 2 quarts of milk, 1 pound of beef, and two eggs. The food value of the ration pictured on the cover is practically the same as in figure 1, but there more bread is used and a little more meat is given to make up for the eggs shown in figure 1. The combinations of food materials shown in these pictures are no better than many others. By studying them in connection with what is said in the text the housekeeper may understand better how to make wise combinations of her own.

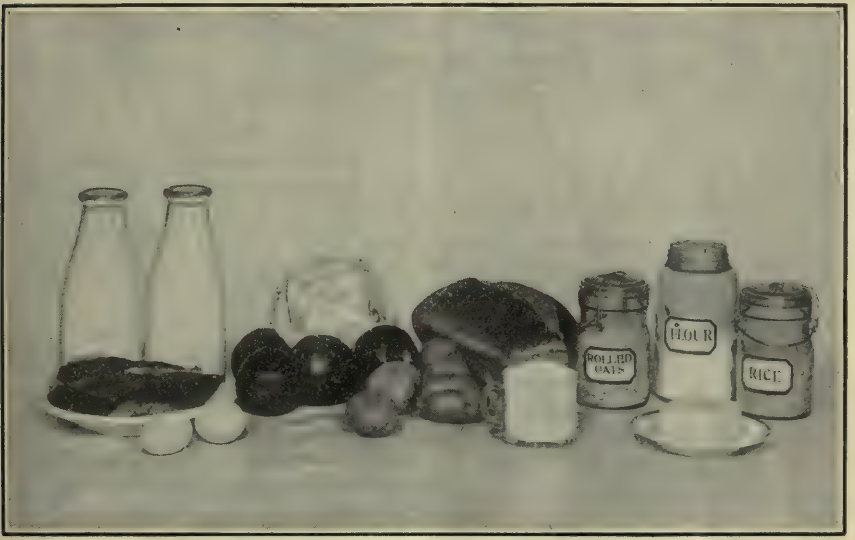

FIG. 1.—A day's food for a family of five.

In the combinations of food materials here pictured bread and other preparations of cereals are used as freely as they can conveniently be without making the ration one sided or unattractive. Such cereal foods form a very wholesome and economical basis for the diet, whether the cereal is used as a breakfast dish, as flour or meal in bread and cakes, or in other ways. A diet equally nourishing and wholesome might be planned with less cereal, but this would make it necessary to increase the amount of the more costly foods, such as meat, fruits, vegetables, and sweets. When cereals are used as largely as in the diet just described it is most important that they be made as attractive as possible. This means good bread, well-cooked and carefully salted breakfast cereals, and inexpensive but well-made and seasoned cakes and puddings. Rice, macaroni, and hominy can often be made more appetizing and nutritious by combining with them small amounts of materials which are not so cheap and have more distinctive flavors. Among these are meat and cheese, and onion, tomato, and other seasoning vegetables. Examples of such combinations are rice and meat, meat pie, or meat with dumplings; macaroni and cheese; tomatoes cooked with bread crumbs or rice; and cereal and fruit puddings, or cereal and milk puddings.

Food materials such as those shown in the pictures may be combined into three meals in many ways. The following meals are given, not because they are recommended above many others that might be used, but simply to show that such foods can be combined into dishes such as are commonly used in American homes.

SAMPLE MEALS FOR A FAMILY.

(Man, woman, and three small children.)

BREAKFAST.

Fruit, 1¼ pounds of fresh fruit (equivalent to 3 medium-sized oranges, 5 small apples, or a quart-box of strawberries), or 3 or 4 ounces of dried fruits (equivalent to 10 or 12 dates or 4 or 5 figs).

Cereal breakfast food, 4 ounces before being cooked, or about 1½ pints after it is cooked. The equivalent in food value in puffed or flaked, ready-to-eat cereals would be 5 or 6 cups.

Milk on cereal, ¼ cup for each person.

Sugar on fruit, on cereal, or in coffee, 2½ level tablespoons or 1¼ ounces.

Bread, 8 slices, or 8 ounces.

Butter, 1¼ ounces, or 2½ cubic inches.

An egg or 2 ounces of meat, fish, or poultry for each older person, and a glass of milk for each young child.

DINNER.

Meat, or fish, ¼ pound per grown person; or, for each child, an egg or a glass of milk.

Potatoes (5 medium sized), 1¼ pounds.

Another vegetable (turnips, spinach, corn, cauliflower, or other), 1 pound.

Bread, 8 slices, or 8 ounces.

Butter, 1¼ ounces, or 2½ cubic inches.

Steamed apple (or other fruit) pudding. (Ingredients: Two cups flour, 2 tablespoons butter, ¾ cup milk, 4 apples, 1 tablespoon sugar.)

Sauce. (Ingredients: One-half cup sugar, 1½ tablespoons flour, 2 teaspoons butter, ¼ cup water, flavoring.)

SUPPER.

A gravy made out of 1 pint of skim milk, ¼ cup flour, 2 level teaspoons butter, and 4 ounces salt or smoked fish (just enough for flavor). To this can be added the egg yolk left from the frosting of the cake. (See below.)

Rice, 8 ounces, or 1 cup, measured before being cooked.

Bread, 8 slices, or 8 ounces.

Butter, 1¼ ounces, or 2½ cubic inches.

One-half of a cake. (Ingredients for whole cake: One-fourth cup butter, ½ cup sugar, 1 egg, ½ cup milk, 1½ cups flour, 2½ teaspoons baking powder.)

Frosting made with 1 egg white and ¼ cup sugar.

WHAT THE DAY'S FOOD SHOULD PROVIDE.

The above meals would supply the following substances in about the right proportions to keep the family in healthful condition and to make the food taste good, providing they were well prepared.

A. *Mineral substances* of great variety (lime salts, compounds of phosphorus, iron, and others).—These are used by the body for building material and are found in all parts of it. They also produce substances within the body tissues which tend to offset acid substances produced in the tissues in the course of digestion of meats and cereals and serve many other important uses. Without fruits and vegetables the meals would be likely to lack certain mineral substances. Without milk they would be lacking in a mineral substance specially needed by children; that is, lime.

B. *Protein.*—Protein serves as fuel for the body and also provides a certain important element, nitrogen, which is needed in the case of children for growth and in the case of both children and grown people to keep the body in repair. Without the meat or meat substitutes (including milk) the meals would be lacking in this body-building material.

C. *Starch.*—This is one of the chief fuels of the body and is supplied mainly by the cereal foods.

D. *Sugar.*—This serves as fuel for the body and to flavor the food. It is found in milk, fresh fruits, and many other materials, but unless small amounts of very sweet materials—sugar itself, sirup, or honey—are used, the diet is likely to be lacking in it.

E. *Fat.*—This serves as body fuel and also improves the flavor and texture of the food. It is present in meats, nuts, and many other foods, but unless small amounts of specially fat materials, like butter, oil, or cream, are used, the meals are likely to be lacking in it. Moreover, dishes cooked without a certain amount of fat and meals served without butter or some substitute seem, to most persons, dry and unpalatable.

F. *Cellulose.*—This is the material which makes up the framework of plants. It gives bulk to the diet and may tend to prevent constipation. Without the fruits and vegetables the meals would be lacking in this important element.

G. *Certain newly discovered substances in very small amounts*, which are believed to play an important part in keeping people well and in promoting the growth of children. Without milk in the diet some of these substances, particularly those necessary for children, would be lacking, and without meat, milk, eggs, fruits, and vegetables others needed by persons of all ages might not be present in sufficient amounts.

H. *Flavorings and condiments.*—In most families some materials are used in preparing or serving food which add to the attractiveness of the meals without furnishing the body any nourishment. Among these are salt, pepper, vinegar, lemon juice, spices, seasoning herbs, horse-radish, flavoring extracts, and many other materials often spoken of as "condiments." These are not discussed at length, because they are not absolutely needed by the body. They may, however, be very useful in making an otherwise unattractive diet taste good. In fact, the secret of making inexpensive meals attractive lies largely in the skillful use of seasoning and flavors, and in this way they may well be worth the cost they add to the diet even if they do not increase its actual food value.

Any kind of food contains one or more of the substances just described, and they are combined in as many different ways as there are kinds of food. A satisfactory diet contains all of them and each in its proper proportion, and the problem of planning meals is really that of choosing foods which will do this.

GROUPING FOODS TO SHOW THEIR USES.

Perhaps as easy a way as any to select the right foods is to group the different kinds according to their uses in the body and then to make sure that all the groups are represented regularly in the meals. Fortunately no more than five groups need be considered: (1) Fruits and vegetables; (2) meats and other protein-rich foods; (3) cereals and other starchy foods; (4) sweets; and (5) fatty foods. The materials under each of these heads have their special uses. It will be helpful, therefore, for the housekeeper to form the habit of thinking of the many different kinds of food which she handles as grouped in some such way as the following:

Group 1.—Fruits and vegetables, such as apples, bananas, berries, citrus fruits, spinach and other greens, turnips, tomatoes, melons, cabbage, green beans, green peas, green corn, and many other vegetables and fruits. Without these the food would be lacking in mineral substances needed for building the body and keeping it in good working condition; in acids which give flavor, prevent constipation, and serve other useful purposes; and in minute quantities of other substances needed for health. By giving bulk to the diet they make it more satisfying to the appetite.

Group 2.—Meat and meat substitutes, or protein-rich foods: Moderately fat meats, milk, poultry, fish, cheese, eggs, dried legumes (beans, peas, lentils, cowpeas, peanuts), and some of the nuts. These are sources of an important body-building material, protein. In the case of children part of the protein food should always be whole milk.

Group 3.—Foods rich in starch: Cereals (wheat, rice, rye, barley, oats, and corn) and potatoes (white and sweet). Cereals come near to being complete foods, and in most diets they supply more of the nourishment than any other kind of food. It is not safe, however, to live only on cereals. The grains may be simply cleaned and partially husked before cooking, as in cracked wheat and Scotch oatmeal; they may be ground into flour and used as the basis of breads, cakes, pastry, etc.; or they may be partially cooked at the factory, as in many breakfast preparations; or they may be prepared in the form of such pastes as macaroni, noodles, etc. In all these forms they furnish the body with the same general materials, though in different proportions.

Group 4.—Sugar (granulated, pulverized, brown, and maple), honey, molasses, sirup, and other sweets. Unless some of the fuel is in this form the diet is likely to be lacking in flavor.

Group 5.—Foods very rich in fat: Bacon, salt pork, butter, oil, suet, lard, cream, etc. These are important sources of body fuel. Without a little of them the food would not be rich enough to taste good.

Some food materials really belong in more than one group. Cereals, for example, supply protein as well as starch; potatoes supply starch as well as the mineral matters, acids, cellulose, and body-regulating substances, for which they are especially valuable; and most meat supplies fat as well as protein. For the sake of simplicity, however, each material is here grouped according to the nutrient for which it is usually considered most valuable. These points are all brought out in more detail in other bulletins which discuss the special groups.

The lists given below show some of the common food materials arranged in these five groups. If the housekeeper will consult them in planning meals until she has learned where each kind of food belongs, she will have taken the first step toward providing a diet which will supply all the food needs of her family. It will be only one step, to be sure, but it should prevent two mistakes—that of serving meals that have not sufficient variety, and that of cutting down in the wrong places when economy either of time or money is needed:

GROUP 1.—*Foods depended on for mineral matters, vegetable acids, and body-regulating substances.*

Fruits:
- Apples, pears, etc.
- Bananas.
- Berries.
- Melons.
- Oranges, lemons, etc.
- Etc.

Vegetables:
- Salads—lettuce, celery, etc.
- Potherbs or "greens."
- Potatoes and root vegetables.
- Green peas, beans, etc.
- Tomatoes, squash, etc.
- Etc.

Group 2.—*Foods depended on for protein.*

Milk, skim milk, cheese, etc.
Eggs.
Meat.
Poultry.
Fish.
Dried peas, beans, cowpeas, etc.
Nuts.

Group 3.—*Foods depended on for starch.*

Cereal grains, meals, flours, etc.
Cereal breakfast foods.
Bread.
Crackers.
Macaroni and other pastes.
Cakes, cookies, starchy puddings, etc.
Potatoes and other starchy vegetables.

Group 4.—*Foods depended on for sugar.*

Sugar.
Molasses.
Sirups.
Honey.
Candies.
Fruits preserved in sugar, jellies, and dried fruits.
Sweet cakes and desserts.

Group 5.—*Foods depended on for fat.*

Butter and cream.
Lard, suet, and other cooking fats.
Salt pork and bacon.
Table and salad oils.

Thinking of foods according to the group to which they belong or according to the nutrient which they supply in largest amount will help the housekeeper to see whether in the meals she plans she has supplied all the different materials needed, especially whether there is the necessary, though small, amount of tissue-building mineral matters and body-regulating materials (group 1), and of tissue-building protein (group 2). When she has made sure that these are present, she may safely build up the bulk of the diet from whatever materials from the other groups that seem economical, wholesome, and appetizing. By means of this grouping she will be reminded that meals consisting only of cereal mush (group 3) served with butter (group 5) and sirup (group 4) would not be a complete ration, and would almost surely be lacking in body-building material, because there are no foods from either group 1 (fruits and vegetables) or group 2 (protein rich). It will become clear, also, that a school lunch of a kind far too frequently served, consisting of bread and cake, is lacking in the same way, and that a glass of milk (group 2) and an apple or an orange (group 1) would make it far more nearly complete. She will learn the wisdom of serving fruit (group 1) rather than a whipped-cream dessert (group 5) or a suet pudding (groups 3 and 5) after a course including a generous portion of fat meat (groups 2 and 5).

The grouping will also help the housekeeper who wishes to save money or time to simplify her meals without making them one-sided or incomplete. For example, if she has been serving bread, potatoes, and rice or hominy in one meal, she will see that one or even two of them may be left out without omitting any important nutrient, providing a reasonable quantity of the one or two remaining is eaten. It will show her that a custard which is made of milk and eggs, two foods from group 2, would hardly be needed after a meal in which a liberal supply of meat had been served, provided one ate heartily of all, and that a child does not need milk at the same meal with an egg or meat. It will suggest that baked beans or other legumes, or thick soups made of legumes, are substitutes for meat rather than foods to be eaten with meat.

This method of planning prevents substituting one food for another which has an entirely different use. It prevents the housekeeper, for example, from trying to give a pleasant variety by using an extra amount of cakes or sweet desserts in the place of fruit and vegetables when the latter seem difficult to obtain. Sugar is nutritious and has a valuable place in the diet, but the nourishment it furnishes is fuel and not the body-building and body-regulating materials which are found in fruits and vegetables, and it is not safe to cut them out, even if the meals can be made attractive without them. Fortunately, they are not always so hard to obtain as it seems, and the wise housekeeper will make every effort to supply them. In general, economy within each group is safer than using an inexpensive food from one group in place of an expensive one from another group.

Thinking in terms of these groups will also help when laying in supplies. Dried peas and beans and dried fish, canned fish, and meat, and some kinds of cheese keep for a long time and can be used in place of fresh meat in an emergency. Fruits and vegetables put up when they are abundant will help to supply this important group in winter.

Farm women can look even farther ahead, and often can plan to raise a variety of foods for use when it is difficult to buy at reasonable prices; for example, enough beans to give the family a generous supply. Though navy beans have been most largely used in this country, there are many other good and easily grown kinds that can be chosen to give variety. In the South cowpeas should not be overlooked. If sugar is high in price honey can be produced, and homemade or purchased sorghum, maple, or cane sirup can be used.

HOW TO TELL WHETHER OR NOT THE DIET IS ADEQUATE.

It is very hard for a housekeeper to know exactly how much of each of the food substances or nutrients her family needs or exactly how much of each she is giving them. The exact amount which each person needs depends upon age, sex, size, and amount of work done with the muscles. An elderly person, or one of quiet habits, needs less food than a vigorous, young one; a large person more than a small one; a man more than a woman; grown persons more than children; and a farmer working in the hayfield, a mechanic, or a football player more than a man who sits at his desk all day.

In order to calculate exactly how much starch, sugar, fat, protein, etc. (or, what is equivalent to this, how much protein and energy) the family needs one would have to know exactly how much muscular work each member was performing and also exactly how much of the different nutrients each food contained and exactly how much each person would eat. This, of course, would mean a great deal of figuring. Fortunately, such exactness is not necessary in ordinary life. If a little too much or too little of one nutrient is provided at a single meal or on a single day a healthy body does not suffer, because it has ways of storing such a surplus and of using its stored material in an emergency. The danger would come if the diet taken week in and week out always provided too much or too little of some one nutrient. Against this danger the housekeeper can more easily protect her family.

Habit and custom help greatly, because they usually are based on what the experience of generations has proved is wise and healthful, though, of course, there are bad habits and outgrown customs in food as in everything else. Good food habits, it must be remembered, include more than cleanliness and order in everything that has to do with food and meals and leisurely ways of eating. Equally important are a liking for all kinds of wholesome foods, even if they have not always been used in one's home or neighborhood, and eating reasonable amounts, without being either greedy or overdainty. Every effort should be made to train children in such good food habits. If older people have not learned them, they, too, should try to do so, for such things are very important not only to health but also to economy. To refuse to eat some wholesome dish simply because one is not accustomed to it may prevent the use of some very desirable and economical food. To feel that there is any virtue in providing more food than is needed shows poor taste as well as poor economy.

The health and appearance of the family are a good test of the wholesomeness of their diet. If they are strong, well developed for their ages, free from ailments, and full of energy and ambition, one may safely say their food agrees with them. But if they are listless and ailing, or not as well developed either physically or mentally as they should be, and if a competent physician finds that there is no special disease to account for these bad symptoms, a mother may well ask herself if the food is right, and if not, how she can make it so.

In such cases she might, for instance, apply for information on food d diet to her State leader in agriculture and home economics and to home-economics department of her State agricultural college.

GENERAL SUGGESTIONS.

It is believed that it is impossible to plan the meals for a family wisely without at least as much knowledge of how different kinds of food serve the body as this bulletin has given and that the safest short cut to good planning lies in considering foods in the five groups here described. Ways of making economical use of the materials in each group can not be discussed in this bulletin, but a few general suggestions for getting the most for one's money in the matter of food may be made here.

Use cereals (flour, meal, cereal breakfast foods, etc.) freely, taking pains to prepare them with great care and to vary the kind used from day to day if necessary to keep people from tiring of them.

Remember that a quart of whole milk a day for each child, to be used as a beverage and in cookery, is not too much.

Remember that while skim milk should never be substituted for whole milk as the principal food in a child's diet, it is as valuable as whole milk as a source of protein and mineral matters in the general diet.

Remember that, except in the case of milk for children, the amount needed of foods specially useful for body-building purposes—that is, meats and meat substitutes, fruits, and vegetables—is not large, but what is needed is needed very much.

Do not be ashamed to plan closely. Thrift in food means providing enough food, neither too little nor too much.

Notice carefully how much of such staples as flour, sugar, milk, cooking fat, etc., is used each week for a month, and see if there are any ways of cutting down the quantity consumed.

Buy nonperishable materials in quantities if better prices can be secured and there is a good storage place in the home. Neighbors can sometimes club together to get lower rates.

Try to make the dishes served of such size that there will be enough to satisfy the appetite of the family and no unnecessary table and plate waste.

Do not be above noticing whether anything usable is thrown away with the garbage, which always shows how thriftily food is used in a household.

Many inexpensive materials can be made attractive and the diet can be pleasantly varied by a wise use of different flavorings.

"Finicky" tastes in food often prevent the use of many valuable materials which might be the means of saving money.

Good food habits are an important part of personal hygiene and thrift. Children get such habits by having suitable amounts of suitable foods served to them and then being expected to eat what is set before them.

True economy lies not only in buying wisely, but also in making the fullest possible use of what is bought.

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MARKETING LIVE STOCK IN THE SOUTH

SUGGESTIONS FOR IMPROVEMENT

S. W. DOTY
Assistant in Marketing Live Stock and Meats

FARMERS' BULLETIN 809

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Markets and Rural Organization
CHARLES J. BRAND, Chief

Washington, D. C. April, 1917

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THE outlet for southern farmers' live stock lies chiefly with local butchers and shippers, and therefore is limited and often unsatisfactory. Not uncommonly farmers slaughter their animals without previously arranging for the sale of the dressed carcasses and, because of the perishable nature of their product, are forced to sacrifice it on an oversupplied market.

Local packing houses have benefited farmers accessible to them by providing a year-round market. Cooperative shipping and marketing clubs, local live stock buying companies, and the establishment of specified market points, with sales on advertised dates, also have improved marketing conditions greatly.

Many farmers market their hogs as cured meats, which are sold to dealers or to consumers. In preparing farm-cured meats in the South, artificial refrigeration is desirable. This may be provided by individual or community meat-curing houses. Some local ice and cold-storage plants cure meats for farmers; others purchase the dressed hogs and cure on their own account. Ice plants might extend this business.

These local marketing plans have proved successful in various communities and have increased the number of live stock produced. They are therefore offered in this bulletin as suggested remedies to communities with inadequate markets.

MARKETING LIVE STOCK IN THE SOUTH: SUGGESTIONS FOR IMPROVEMENT.

CONTENTS.

	Page.
Need of better local markets for live stock	3
Local markets and methods of marketing commonly followed	3
Local marketing of stock on foot	5
Cooperative live stock shipping	5
Tennessee lamb and wool marketing clubs	7
A Mississippi commercial club's marketing plan	8
Cattle sales of South Carolina	9
Marketing farm-cured meats	10
The southern ice plant as a local market	11
Municipal or public abattoir as an aid in the local marketing of live stock	12
Meeting market demands	13

NEED OF BETTER LOCAL MARKETS FOR LIVE STOCK.

FREQUENTLY the statement is made that the live-stock problem of the South is more essentially one of production than of marketing; in other words, that the live-stock markets and transportation facilities will not be improved materially until the South raises stock in sufficient numbers to attract buyers and to warrant the expenditure of capital for equipment and service. Nevertheless, the lack of a ready market and the unsatisfactory prices received by the small farmer undoubtedly have helped to retard the development of the live-stock industry in many sections of the South.

Since it is largely to the small farmers that the South must look for the desired increase in live-stock production, it is essential to offer them encouragement in the way of better marketing facilities. This can be done by establishing local markets of such a nature that the farmer will be assured of an opportunity to dispose of his stock at a fair market price.

LOCAL MARKETS AND METHODS OF MARKETING COMMONLY FOLLOWED.

Under present conditions in the South a large part of the live stock is sold by farmers to local butchers for retail trade, and to local dealer-shippers for shipment to market.[1] In the nine Southeastern

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[1] U. S. Department of Agriculture, Office of the Secretary, Report No. 113, Meat situation in the United States, Part V, Methods and costs of marketing live stock and meats. 1916.

NOTE.—The purpose of this bulletin is to place before southern farmers who produce stock in small lots and who are experiencing difficulty in marketing their live stock the more important local marketing plans which have been found successful in certain communities and which are practicable under southern conditions.

States (Tennessee, North Carolina, South Carolina, Georgia, Florida, Louisiana, Mississippi, Alabama, and Arkansas) 47 per cent of the cattle marketed for meat purposes is sold to local butchers either on foot or as farm-dressed carcasses; 36 per cent is sold to local dealer-shippers for shipment to market; and 7 per cent is shipped by owners in car lots, the remaining 10 per cent being sold to local packers, to packers' agents for shipment, or for shipment to feeding points.

Calves are marketed largely to local butchers, the average from the nine States being 56 per cent, while 35 per cent is sold to local dealer-shippers. Sheep are marketed in a similar manner, 55 per cent being sold to local butchers and approximately 30 per cent to local dealers for shipment to market. Hogs also are marketed largely locally, 70 per cent being sold either on foot or as farm-dressed carcasses to local butchers for retail trade, and as farm-cured meats and sausage. Seventeen per cent is sold to local dealer-shippers for shipment to market and 7 per cent is shipped in carload lots by owners, the remainder being sold largely to local packers and to packers' agents for shipment.

A very common method of marketing employed by the small farmers is to slaughter the animals on the farm and sell the dressed carcasses to local retail dealers, or to consign them by express to commission men for sale in the larger cities. Approximately 6 per cent of the calves, 9 per cent of the cattle, 12 per cent of the sheep and lambs, and 16 per cent of the hogs of the ninth Southeastern States are marketed in this manner.

In many cases animals are killed and offered for sale regardless of market conditions. Frequently advantage is taken of cool weather to kill and dispose of hogs, with the result that the dressed carcasses must be sold on a glutted market, and, being a perishable product, must be disposed of at any price obtainable. An example, which is only one of many, was observed at a small town in Louisiana during the winter of 1915–16, where each time the weather became cooler 8 or 10 dressed hogs were offered for sale when there was a demand for but 1 or 2. Such a method is, of course, most unprofitable to the farmer. A number of instances have occurred in southern cities where dressed beef ordinarily valued at 7 to 8 cents a pound was sold by farmers for 3 to 4 cents, and dressed hogs valued under ordinary conditions at 8 to 10 cents a pound sold for 2 to 3 cents because of a temporary oversupply of fresh meats in these towns. The farmers could have avoided these losses by finding a market for their meat before slaughtering, by delaying slaughtering until market conditions were improved, or by selling the animals alive on a good market.

Even under normal market conditions the prices paid for dressed carcasses often are not in proportion to the quoted live-weight prices of the animals. In Louisiana, instances were noted in the autumn of 1916 where farmers were being paid 8 cents per pound for dressed hogs when at the same date hogs of similar grade were quoted at 9 to 9¼ cents per pound live weight on the Fort Worth market. Similar conditions are reported from other sections of the South. Considering, therefore, the prices ordinarily paid the farmer in the South for meat animals, live and dressed weight, together with the labor of killing and dressing and the uncertainty of the meat trade, farm animals in many cases may be sold to better advantage on foot than as dressed carcasses.

LOCAL MARKETING OF STOCK ON FOOT.

The outlets usually available to farmers wishing to dispose of their meat animals on foot are the local dealer-shipper and the local retail butcher. But for farmers located near a packing plant the marketing problem is simplified, as a ready market is provided at all times and better prices than those paid by local dealers usually are obtainable. Such institutions should have all the support possible to help assure their success. Packing plants in the South have experienced difficulty in procuring live stock during the summer months, which has tended to hinder their progress. Farmers should consider the advisability of fitting their hogs for market during different seasons of the year.

Comparatively few farmers are situated near these packing plants. On the other hand, many farmers are located in the vicinity of small towns where the local demand for meats is very limited, and any surplus must be marketed elsewhere. These farmers are dependent upon local dealer-shippers for the sale of their live stock, inasmuch as no one farmer has sufficient stock of his own to make up a full carload for shipment to market. At some points there may be but one shipper, in which case the farmer is compelled to accept the prices offered, although they may be unsatisfactory, while in many communities no live-stock shippers are operating. Such conditions undoubtedly have been the means of retarding live-stock production in many parts of the South.

For the purpose of bettering market conditions for farmers so situated several plans for marketing live stock locally have been developed and found practicable. Such plans might well be adopted in many localities in the South where present marketing facilities are found to be inadequate.

COOPERATIVE LIVE STOCK SHIPPING.

Of the various marketing plans under discussion, undoubtedly cooperative shipping is being most generally adopted in the United States. This is a method by which producers of live stock in less-than-carload lots are enabled to ship their animals to centralized live-stock markets. Farmers taking advantage of this method of marketing receive prevailing market prices for their stock less the cost of marketing. They are independent of local buyers and save the profits realized by these buyers. Also by means of a sinking fund set aside for the purpose, farmers are reimbursed for animals killed or injured in transit. Associations for marketing live stock in this manner are simple in organization and no capital is required, inasmuch as it is entirely a consignment business and farmers are paid for their stock when returns from a shipment are received.

Cooperative live stock shipping associations[1] have met with marked success during the last few years in a number of the Middle Western States. The United States Department of Agriculture has a list of approximately 750 organizations in 15 States that are shipping stock in this manner, and the movement is extending rapidly. Minnesota, with a total of more than 200, leads in the number of these associations; and estimates by the crop and special live stock reporters of the Bureau of Crop Estimates of the United States Department of Agriculture indicate that approximately 25 per cent of the cattle and hogs and 15 per cent of the calves and sheep marketed from that State are shipped through these associations.

Cooperative live stock shipping is adapted to the needs of many communities in the South, particularly those which are situated within convenient shipping distances of large centralized live stock markets or packing houses, and which do not have adequate local markets. A few associations, primarily formed for shipping hogs, already have been organized in the South, and one of the results noted has been the adoption of better production methods in these localities. When it is known that there is a chance to ship hogs direct to a good market, where they will be sold on their merits, instead of selling them to local buyers at arbitrary prices, farmers usually are more inclined to give their hogs special care and not to allow them to run at random and feed on whatever they can find.

An instance of the need for some plan of marketing which will enable farmers with a few hogs to reach centralized markets was noted recently in Louisiana. A farmer who had 19 hogs to market was unable to dispose of them at near-by towns, since the local butchers were oversupplied with fresh meats, and the local shippers were indisposed to handle the hogs. Accordingly, the farmer purchased 17 hogs from a neighbor, loaded the 36 in a car and shipped them to market. Although it was a light car, the profit on the 17 head bought paid for the time spent in the transaction and all costs of making the shipment, including shrinkage on the original 19 head.

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[1] Doty, S. W., and Hall, L. D., Cooperative live stock shipping associations, U. S. Department of Agriculture Farmers' Bulletin 718, 1916.

Humphrey, J. R., and Kerr, W. H., A system of accounts for live stock shipping associations, U. S. Department of Agriculture Bulletin 403, 1916.

It is generally considered that conditions which will be favorable to the organization of associations for shipping stock cooperatively in the South must be developed gradually. Until live stock is produced in the South in sufficient quantities to warrant shipping organizations for the purpose, a very simple plan of cooperative shipping in which several farmers combine their stock to make up carload lots for shipment may be followed. Many associations in the North have resulted from such a plan and undoubtedly shipping associations in the South will be formed largely in this manner.

TENNESSEE LAMB AND WOOL MARKETING CLUBS.

Lamb and wool marketing clubs have been in successful operation in Tennessee for more than 25 years. They were the outcome of unsatisfactory marketing conditions in the lamb-producing sections of Tennessee. The plan originated at Goodletsville, where there is a club with a membership of 50 persons living within a radius of 3 miles from the shipping stations, and its success has prompted farmers in other sections of Tennessee to organize in a similar manner.

The organization of these clubs is comparatively simple. The officers consist of a president and a secretary-treasurer, who, with three other members, form an executive committee, the chairman of which is the secretary-treasurer. The annual meeting for the election of officers is held early in the spring, that each member may report the number of lambs and the amount of wool that he will have to sell.

The secretary-treasurer advertises for sealed bids on the lambs owned by the club. The advertisement indicates the number, grade, and quality of the lambs and the date shipment will be made. The lambs are then sold at the shipping point to the highest bidder, the executive committee reserving the privilege of rejecting all bids in case they seem too low. On the shipping date the executive committee is on hand to grade the lambs brought in by each farmer. All lambs not up to the advertised standard are returned to the farmer, who either holds them over for some future shipment or sells them at a sacrifice. This has the beneficial influence of training the owners to deliver only those lambs which will come within the grades advertised by the committee.

The day for the wool sale is advertised, that bidders may be on hand to see the fleeces, which are graded into No. 1, clear; No. 2, slightly burry; No. 3, burry; and No. 4, hard burry. Each grade is weighed, and sealed bids are received by the committee, which also reserves the privilege of rejecting all bids.

The farmer who owns a small flock of ewes has the same advantage in marketing his lambs as the large producer. Expenses are made proportionate and all receive the benefit of competitive bids. The results are seen principally in the better prices obtained. It is stated freely that the club members receive from $1 to $2 a hundredweight more for lambs of the same grade and 2 cents per pound more for wool than farmers in the community who have not the benefit of cooperative selling. The members are encouraged to follow uniform methods in breeding and handling their flocks, with the result that the clubs have an established reputation in many of the large markets for the uniformity and high quality of their lambs and wool.

A MISSISSIPPI COMMERCIAL CLUB'S MARKETING PLAN.

A " farmers' stockyards company " was organized at a city in Mississippi in 1912 by a committee of the board of trade. The company is capitalized at $10,000, with $2,500 paid in, this amount having been found sufficient to transact the business of the company. The company was organized primarily to provide the farmers of the surrounding country with a good local market for their live stock throughout the year, with the hope of increasing the production of live stock. The stockholders, who are local business men, receive no dividends, and it is their aim, while maintaining the capital stock unimpaired, to conduct the business so that the farmer will receive the maximum returns for his live stock. The operating expenses of the company therefore are reduced to a minimum. The manager receives $15 for every carload of stock shipped by the company, and the secretary-treasurer a salary of $150 per annum. The rental of the stockyards (an abandoned cotton-compress lot) is secured by charging 5 cents per head for all live stock taken into the yards. Other expenses are the wages of a caretaker and the city water charges.

The company buys live stock in any sized lots on two days of each week throughout the year, paying cash. The prices paid the farmer are those prevailing at the large centralized markets, such as East St. Louis and Fort Worth, minus a small margin to cover the usual marketing expenses. The latter include the operating expenses of the company; the cost of feed at shipping points and en route; freight; shrinkage; and the charges at the market, namely, insurance, yardage, feed, commission, and dockages.

An immediate result as reported by the secretary of the organization has been shown in the higher prices paid by local butchers for all live stock offered and in their readiness to pay cash for purchases, whereas previously it was not uncommon to demand credit extensions from the farmers. On the other hand, since the work of the company has demonstrated the fact that live stock can be bought and shipped to centralized northern and southern markets, local dealers have started operations in the vicinity, which have curtailed the business of the stock yards company. An extended interest in live-stock production by farmers in the surrounding country has been noted.

CATTLE SALES OF SOUTH CAROLINA.

The extension department of Clemson Agricultural College, South Carolina, cooperating with the United States Department of Agriculture, has instituted a plan for marketing cattle which has been followed two years and has proved sufficiently successful to warrant its continuance. The plan is a direct outgrowth of a movement to increase the production and fattening of cattle in the State. At the outset the main purpose of the work was to interest small farmers in raising and feeding cattle, and by improving feeding methods to show them the advantages to be derived from putting their stock in marketable condition. With this object in view a number of farmers in various sections of the State were induced to feed from two to five head of cattle under the direction of live-stock specialists employed jointly by the extension department of the college and the United States Department of Agriculture. At this juncture the question of marketing these cattle arose. The local markets at this time, in many sections of the State, were found to be unsatisfactory, and therefore very little encouragement was offered the farmers to increase or improve their live stock. To overcome these difficulties the following plan was outlined: Three places which would be accessible to the farmers feeding cattle were designated, and a market day was arranged for each place. On the days set for the sales the cattle were assembled at these points, and by previous arrangement buyers from several of the northern markets were present to bid on the cattle. The sales were conducted on the private-sale plan rather than as auctions. The results were satisfactory from the standpoint of both buyer and seller, the cattle netting from one-half to 1 cent a pound more than local buyers were offering.

Aside from the benefits derived from the market itself, the educational feature of having these sales at home was of no little value to the farmers. It enabled them to study the grades under which cattle are sold and to see the reason one lot of cattle brought a higher price than another. Cooperation on the part of the railroads in offering better shipping facilities has added to the success of the sales. Expert cattle salesmen were obtained to conduct the sales the second year, which added to their success.

The extent to which this plan is practicable for other parts of the South will be determined wholly by local conditions. It is thought by many who are familiar with southern conditions that until the live-stock industry is well established in the South a marketing plan of this kind is more adaptable to some sections than cooperative shipping.

MARKETING FARM-CURED MEATS.

Experience has shown that it is practicable for the average southern farmer to cure the pork needed for home use. The possibility of marketing hogs in the form of cured meats also is worthy of consideration. Local conditions will determine the extent to which this may be practiced. It depends largely on the opportunity open to the farmer to dispose of his hogs, alive or as dressed carcasses, at satisfactory prices to local shippers or butchers or otherwise.

In many communities the only market for the farmer with a small number of hogs is the local retail butcher, and ordinarily he is oversupplied with dressed hogs and other fresh meats during the winter months. Under such conditions curing meat on farms for market may be practiced profitably, as the meat can be held until prices are favorable. Farmers in many localities are employing this method successfully, notably in Brooks County, Ga., where it has been an important feature of the farming operations for 25 years. A ready local market is provided in the South for farm-cured meats that are handled properly and correctly trimmed and cured. The meat may be sold to wholesale grocers and local retail butchers or to private customers. In the latter case, shipments consisting largely of hams, bacon, and sausage may be made by parcel post or express.

It is not intended to discuss in this bulletin the methods of curing meat. This work demands careful attention on the part of the farmer, especially when he does not have refrigeration. A great deal of meat has been lost during the curing process because of weather conditions. However, if the following important preliminaries are observed, and the rules for curing followed carefully, the amount of spoiled meat may be reduced to a minimum:

1. Be certain that the animal is healthy and in good condition.
2. Keep hogs off feed and with plenty of accessible water for 24 hours previous to killing.
3. Be sure the animal does not become heated previous to slaughter.
4. Be sure the carcass is chilled thoroughly or cooled out before the meat is cut up to be put into cure.
5. Cut all pieces uniformly and trim all ragged edges carefully. A ham or piece of bacon which is attractively shaped is more salable than one which is not.

Because of climatic conditions in the Southern States, particularly the Gulf States, some form of artificial refrigeration will aid and safeguard the curing process. This may be supplied by a private meat-curing house on the farm or by a community meat-curing house or by taking the meat to a local ice plant to be cured.

In a test conducted in a small meat-curing house in southern Georgia, it was estimated that the cost of curing the meat was not more than three-fourths of a cent a pound, including the cost of the ice. This house, which is 9 by 9 feet in size, has been found to be sufficiently large for the average farmer. Meat houses, varying in size from 6 by 8 feet to as large as 16 by 30 feet, recently have been built and operated successfully by at least 10 farmers in southern Georgia, and it is predicted that many more of these houses will be built in the near future by farmers in this section.

THE SOUTHERN ICE PLANT AS A LOCAL MARKET.

The curing and handling of pork products opens an extensive field to ice plants throughout the South. For several years the managers of a few plants have cured meat for farmers at a specified price per pound. A more recent development of the business, however, has been the purchase of dressed hogs from farmers by the ice-plant management. This plan was inaugurated at Canton, Miss., during the winter of 1913–14, where it since has become an important feature of the ice company's business.

Information obtained from the managers of ice plants who have had experience in curing meat for farmers indicates that the plan has been profitable to the ice-plant owners and of considerable service to farmers in the respective communities.

One ice company which cures meat for farmers charges 1 cent per pound for curing, 2 cents for curing and smoking, and 3 cents for curing, smoking, and wrapping. These charges include all labor, salt, and other material, and are based on green weight of meat. The farmer delivers the meat to the plant cut into desired pieces for curing. The management reports that approximately 30 tons of meat were cured at this plant during the winter of 1913–14, 55 tons during the winter of 1914–15, and approximately 120 tons during 1915–16.

Fourteen plants in Georgia and one in Mississippi are reported to be conducting the business after this plan. While no figures are available to show the actual cost of curing meats, reports of managers who have conducted the business indicate that a charge of 1 to 2 cents a pound, depending upon the local conditions and the amount of meat in cure, will return a reasonable profit to the plant and at the same time be fair to the farmer.

Where the owners of ice plants make a business of buying the hogs and selling the cured products, dressed hogs are purchased from the farmer. The meat is handled in about the same way as at the smaller packing plants, and the cured meat and other products are sold locally. The management of one ice plant which has conducted this business for several seasons reports that the number of hogs produced in the community has been practically doubled during this period. This increase is attributed largely to the market which the ice plant has provided. The buying records of this plant for the winter of 1914–15 show that the hogs delivered to the plant average three for each patron. These facts show that the local market for hogs thus provided by ice plants is of particular value to the small farmer. He receives more for his hogs than he otherwise would, a fair profit is made at the ice plant, and a good home product is offered the consumers at a reasonable price.

During the winter of 1914–15 the practice of purchasing hogs from farmers was taken up at three plants in Arkansas, and, under the supervision of a representative of the Department of Agriculture, it was extended to 10 ice or cold storage plants in that State during the winter of 1915–16. As a result of the work in Arkansas, at least one ice company in Louisiana and two in Mississippi are now buying dressed hogs from the farmers.

Not only does this business furnish the farmer a steady and substantial market for his hogs during the winter months, but it makes it possible for the owners of ice plants to utilize their equipment and storage rooms as a source of revenue during a period when the ice business is dull. It is not likely that a very large number of hogs will be handled by any one ice plant. However, this outlet offers encouragement to farmers who are starting in the business of raising hogs and gives them a market for their surplus while production is being increased and other markets or packing-house centers are being established.

MUNICIPAL OR PUBLIC ABATTOIR AS AN AID IN THE LOCAL MARKETING OF LIVE STOCK.

Centralized slaughtering at abattoirs either municipally owned or privately owned and operated under city inspection is increasing each year throughout the country. Investigations by the United States Department of Agriculture indicate that at least 22 cities in 13 States now have such plants, the greater number of which are located in the South. Five of the 7 cities which own abattoirs and 12 of the 15 which have privately owned public abattoirs are southern cities.

The main purposes in establishing these abattoirs are to enable municipalities to carry out effectively a thorough system of inspection, to overcome insanitary conditions, and to provide refrigeration facilities for locally slaughtered meats. But many features in connection with institutions of this kind are of interest from the standpoint of marketing. Principal among these are the utilization of offal, practically all of which is wasted in the old type of local slaughterhouse, the lessening of the percentage of cut hides, and the better appearance of dressed carcasses because of improved facilities and more careful handling. The local demand for home-grown meats, particularly beef, has increased in several instances with the advent of the public abattoir. This has tended toward improving the local market for live stock from the surrounding territory.

The charges for slaughtering vary somewhat in the different cities, depending largely on the services rendered and the distribution of offal. The more common rates are $1.25 per head for cattle and 75 cents per head for hogs, sheep, calves, and goats. This includes slaughter, two inspections, five days' cold storage, and delivery to any part of the city.

Farmers located near a city or town which has a public abattoir and at which there is a local ice plant, where meat may be cured, are excellently situated to market their hogs as cured meats. Meat can be chilled thoroughly at the abattoir, and if then cured at the ice plant, danger of spoiling during the curing process practically is eliminated.

The municipal abattoir, although a comparatively new undertaking in this country, may be considered a factor in the development and extension of local markets for live stock. It is not without its limitations, however, principal among which are the competition with local butchers and the difficulty of obtaining competent management.

MEETING MARKET DEMANDS.

It is of the utmost importance that the producer of live stock should understand fully the requirements of the market before offering his product for sale. This is true especially of the southern hog producer. So-called "soft pork" is produced in the Southern States because the hogs are fattened on peanuts or similar feeds. The result is that not only the large packers at centralized markets, but many of the smaller packers in Southern States, discriminate against southern hogs, a margin of 1½ to 2 cents per pound in favor of corn-fed as compared with peanut-fed hogs being offered at most markets. As a rule, the large packers buy southern hogs either with a guarantee to "kill out hard" or outright at lower prices. Numerous instances were recorded during the winter season of 1915–16 in which farmers had difficulty in disposing of their hogs, owing to the limited demand of local retail dealers and to the fact that local shippers who furnished the only other outlet would not venture to buy hogs on account of the discrimination against southern hogs at the centralized markets. It is evident, therefore, that farmers who are dependent for the sale of their hogs upon markets of this kind are at a disadvantage unless they produce hogs that will "kill out hard."

Experiments conducted at the Alabama Experiment Station indicate that peanuts, soy beans, or other grazing crops are an essential factor in the most economical production of pork. Such feeds, however, particularly peanuts, when fed alone, produce a soft pork, which is objectionable to the butcher and packer, as well as for home consumption. The experiments indicate also that a soft pork can be hardened very materially if the grazing crops are supplemented by a small amount of corn (2 pounds per hundredweight live weight), and then for a period of three or four weeks before slaughtering the hogs are finished on a full feed of grain (about 4 per cent of live weight, or 1 pound of grain to 25 pounds live weight of hog) and cottonseed meal in proportions of about 4 pounds of grain to 1 of cottonseed meal. Concerning the finishing period of peanut-fed hogs, the following is quoted from Bulletin 154 of the Alabama Agricultural Experiment Station:[1]

> Cottonseed meal has proved to be an excellent supplement to corn, to be used in the short finishing period. It is good for two reasons—first, the gains are made economically when it is used; and, second, the lard and meat are hardened much more rapidly when cotttonseed meal is used along with the corn than when corn is used alone. Corn and cottonseed meal harden the lard and meat more rapidly than does a mixture of corn and tankage. Cottonseed meal, when fed for long periods of time, is a dangerous feed. However, there is no danger of ill results when the cottonseed meal is used for no more than 28 days. If the hogs must be kept in the finishing period for more than 25 to 28 days, the cottonseeed meal part of the feed should be eliminated; from this time on the ration should consist of corn alone, corn and shorts, or corn and tankage.

While rapid progress is being made in the improvement of southern hogs, they do not as yet, generally speaking, dress out as high a percentage as do corn-belt hogs, largely because of the type of hog and the feeding methods practiced. Data relative to this were obtained from packing houses operating in the Southern States. At one plant which slaughtered 6,039 hogs during the months of March, April, May, and June, 1916, the average live weight was 150.8, while the dressed weight was 101.7 pounds, the average dressing percentage being 67.1. Practically all of these hogs were weighed off the cars, with no "fill," and therefore dressed out a higher percentage than if they had been purchased at stock yards and had received a heavy "fill." At another plant tests on 2,640 Tennessee hogs, averaging 140 pounds live weight, showed the dressing percentage to be 71.3, and on 685 Georgia hogs averaging 126 pounds live weight the dressing percentage was 70.1.

In proportion to live-weight prices, the prices for dressed beef and pork necessary to make the same returns to the farmer are not so high as they may appear. For example, a 600-pound cow worth 6 cents a pound on foot would bring $36. The hide weighs about 45 pounds and sells at, say, 20 cents a pound, or $9. Such an animal will dress out about 45 per cent, or a 270-pound carcass. Thus, to give the same return as the live cow at 6 cents a pound the carcass would have to bring $36 less $9, which is $27, or 10 cents a pound.

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[1] Gray, D. T., Ridgway, J. W., and Eudaly, E. R., Corn, soy-bean pastures, tankage, and cottonseed meal for fattening hogs. Alabama Agricultural Experiment Station Bulletin 154, 1911.

Likewise well-fattened hogs (hogs sufficiently fat to dress out 75 per cent carcass when killed) must sell for 8 cents a pound dressed weight to net the same as the live hog at 6 cents a pound. This difference between live and dressed weight prices diminishes with the increase in the dressing percentage of the animal, as indicated in Table I, which shows live-weight prices and the corresponding dressed-weight prices per hundredweight that are necessary to net the same returns for hogs of different dressing percentages. In this discussion it is considered that the offal would balance the cost of slaughter.

TABLE I.—*Comparison of live-weight price with dressed-weight price necessary to net the same returns from hogs.*

[Prices per hundredweight.]

Live-weight price.	Dressed-weight price necessary to net same return for carcasses dressing various percentages.				
	65 per cent.	70 per cent.	75 per cent.	80 per cent.	85 per cent.
$4.00	$6.15	$5.71	$5.33	$5.00	$4.70
4.50	6.92	6.43	6.00	5.63	5.29
5.00	7.69	7.14	6.67	6.25	5.88
5.50	8.46	7.86	7.33	6.88	6.47
6.00	9.23	8.57	8.00	7.50	7.06
6.50	10.00	9.29	8.67	8.13	7.65
7.00	10.77	10.00	9.33	8.75	8.23
7.50	11.54	10.71	10.00	9.38	8.82
8.00	12.31	11.43	10.67	10.00	9.41
8.50	13.08	12.14	11.33	10.63	10.00
9 00	13.85	12.86	12.00	11.25	10.59
9.50	14.62	13.57	12.67	11.88	11.18
10.00	15.38	14.29	13.33	12.50	11.76

A large majority of southern hogs are marketed during the winter months. Prices are lowest during this period, largely because of heavy receipts at markets in all parts of the country. A study of receipts and prices at the leading live-stock markets shows that in the five-year period, 1910–1914, the average price for live hogs was highest during the months of March, April, August, and September, and that the receipts during these months were lowest. An advantage in price, therefore, is to be gained usually by marketing hogs during these months. Although it is not practicable for some farmers to change their production methods to take advantage of this fact, undoubtedly there are many, particularly farmers who are accessible to packing houses in the South, who could well afford to arrange to have their hogs in marketable condition during these months. A more uniform distribution of market hogs throughout the year in the Southern States would benefit many farmers and at the same time assist greatly in the development of the packing industry in the South.

Elimination of the cattle tick[1] is essential to the most profitable marketing of southern cattle, as well as to their most economical production. Aside from its effect on the condition and appearance of the animal, the tick materially reduces the value of the hide. Cattle shipped to market from areas not free from the tick must go to the quarantine pens, unless accompanied by a Federal certificate of dipping before shipment. Not uncommonly it is found that such cattle are discriminated against to the extent of 40 to 50 cents a hundredweight in comparison with other cattle of equal quality outside of the quarantine district.

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[1] Mohler, John R., Texas or tick fever, U. S. Department of Agriculture, Farmers' Bulletin 569, 1914.

Ward, W. F., Effects of cattle tick eradication on the cattle industry of the South, U. S. Department of Agriculture, Bureau of Animal Industry, 1914.

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Revised June, 1

EQUIPMENT FOR FARM SHEEP RAISING

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Of the Animal Husbandry Division

FARMERS' BULLETIN 810

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

Washington, D. C. June, 1917

Additional copies of this bulletin may be obtained from the
Division of Publications, U. S. Department of Agriculture

EQUIPMENT for raising sheep on farms need not be expensive. In mild latitudes little housing is needed, and the main need is for fencing and pastures of sufficient number and size to allow frequent changing of flocks to fresh ground to insure health. Where winters are longer and more severe, buildings and sheds are necessary to furnish protection from storms, though no special provisions are needed for warmth. Dryness, good ventilation, and freedom from drafts are the first requisites of buildings for sheep. Convenience in feeding and shepherding must also be held in mind in locating and planning such buildings or sheds.

Small flocks can be cared for in sections of barns having stabling or feed storage for other stock, but with a flock of, say, 100 ewes separate buildings are desirable. The interior arrangement of these buildings should be such as to require a minimum of labor and the least possible moving of the ewes in doing the feeding and caring for them during the lambing season. A building of this type can also be utilized for fattening purchased lambs to be disposed of before lambing begins in the regular farm flock. A good supply of feed racks, grain troughs, etc., can be provided at small expense and will save labor and prevent waste of feed.

EQUIPMENT FOR FARM SHEEP RAISING.[1]

CONTENTS.

	Page.
Drawings and bills of materials	3
Important features of buildings for sheep	6
A barn for the exclusive use of sheep	10
A combination horse, cattle, and sheep barn	13
A closed sheep shed	15
An open sheep shed	16
A feed lot for fattening lambs	17
Feed racks	18
Grain troughs	21
Lambing pens and creeps	32
Fencing and hurdles	23
Miscellaneous equipment	25

DRAWINGS AND BILLS OF MATERIALS.

The object of this publication is to furnish a practical guide for the equipping of farms for sheep raising. Wide differences in climatic conditions render it impracticable to suggest a particular type of building for all sections; therefore a number of types of barns and sheds are presented. In many cases it will be found satisfactory to construct buildings as shown in the plans. Where this is not advisable the essential features of arrangement can be adopted with such alterations in detail as are rendered necessary by climatic or other fixed features.

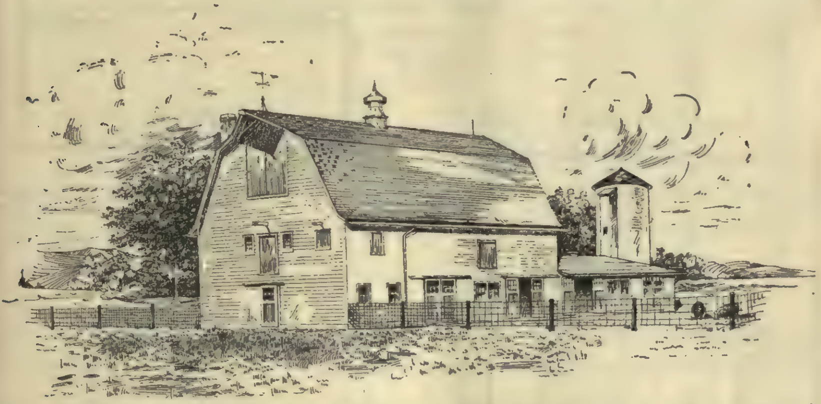

FIG. 1.—Barn for the exclusive use of sheep. In requesting plans and bill of material for this building, mention subject No. 685, serial Nos. 567, 568, and 569.

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[1] The author is indebted to Mr. Wallace Ashby of the Office of Public Roads and Rural Engineering for assistance in the design and preparation of drawings and descriptions of the buildings shown in figures 1 to 11.

The estimated cost of buildings given in the discussions of the sets of plans is based upon average prices for material and labor in May, 1916. Elaborate and expensive structures are not advocated for use in handling sheep. Buildings of this character do not insure economy in management and are not essential to the welfare of the flock.

In deciding upon the amount of equipment other than buildings no set rules can be followed. Peculiarities of individual farms

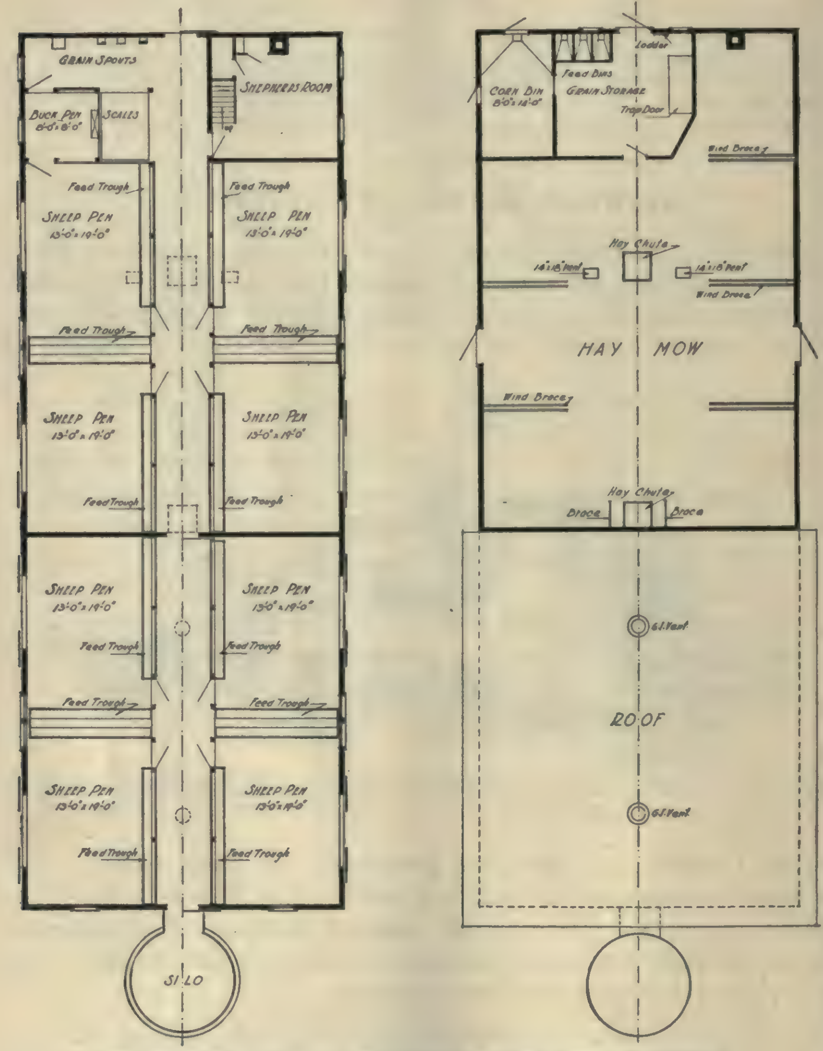

FIG. 2.—First and second floor plans of barn shown in figure 1.

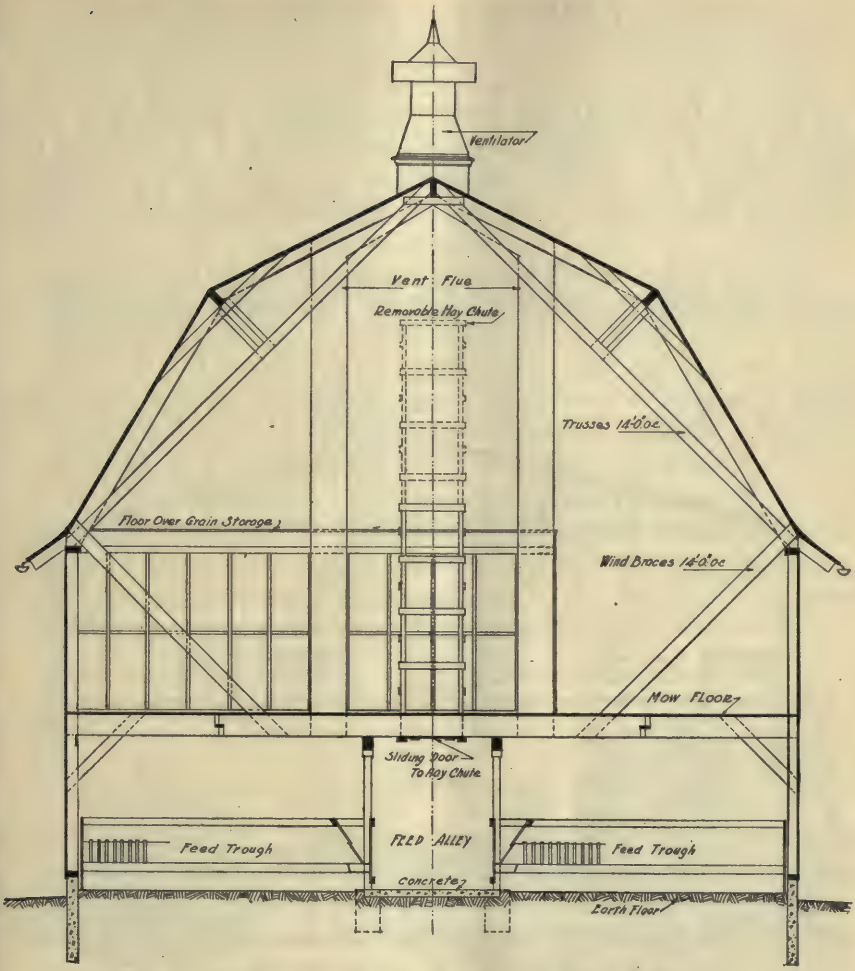

FIG. 3.—Cross section of main part of barn shown in figure 2.

and variations in systems of rearing determine what can be used to the best advantage. The assortment of minor equipment shown is designed to include the range of such material that will permit a selection of what is needed in any particular case.

Working drawings and bills of materials for the buildings shown in this bulletin may be obtained without charge, by those who intend to build, from the Office of Public Roads and Rural Engineering, Department of Agriculture, Washington, D. C. While prints of the drawings will be furnished as long as they are available for free distribution, it is expected that only persons who are interested to the point of building will apply for them.

IMPORTANT FEATURES OF BUILDINGS FOR SHEEP.

LOCATION.

The site for permanent buildings for sheep should first of all be dry and well drained. Ample yard space that is dry and sheltered should be available adjacent to the main barn or shed. A southern slope with sandy soil is especially satisfactory for this purpose.

On most farms it will be advantageous to have the buildings and yards easily reached from the regular pastures or from fields used to grow forage crops for summer pasture. As the flock requires attention many times daily during part of the year, convenience of location in relation to the farm dwelling and to other buildings will effect an economy of time in the performance of routine labor.

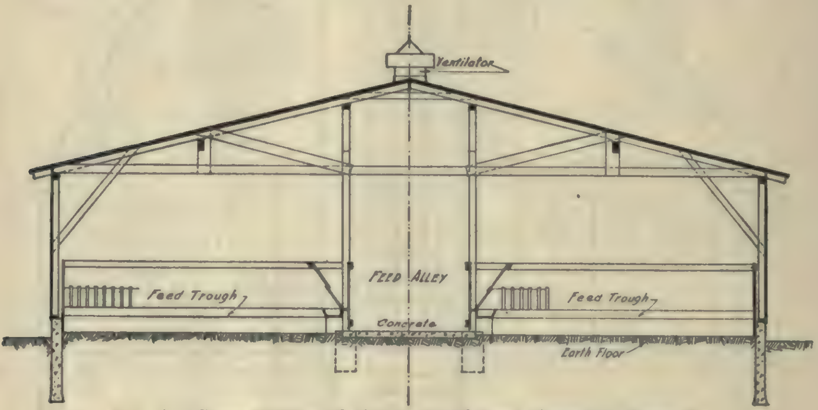

FIG. 4.—Cross section of shed part of barn shown in figure 2.

WARMTH, DRYNESS, AND LIGHT.

Since sheep do not require quarters that are especially warm, a single wall will ordinarily insure sufficient warmth. If lambs are dropped in very cold weather, a temporary covering over the lambing panels described later will answer the purpose, or a small space can be partitioned off in which to keep a few ewes until their lambs become strong.

Shade and protection from heat are peculiarly necessary for sheep. Shade can not always be furnished in pastures, and buildings that are well located and constructed so as to render them cool in summer will often provide greater comfort to the sheep during hot days than would be possible for them out of doors.

Dryness and freedom from draft are most important. Sheep can not possibly thrive in quarters that are damp or dark. In fact, the flock should be shut in only during storms. Abundance of light in all parts of the building and at all times is necessary not only for the health of the sheep but for convenience of the shepherd in caring for them. One square foot of window for each 20 square feet of floor space is necessary. Windows should be placed at a height to insure a good distribution of light, and particularly direct sunlight for the lambing pens during the period the ewes are lambing.[1]

VENTILATION.

Close confinement in poorly ventilated pens is very injurious to breeding ewes. While they should seldom be shut indoors, a part of the flock will usually lie inside at night. At lambing and during storms doors should be closed. For such times it is necessary to provide means of securing fresh air without creating drafts. In a very large building with numerous doors and windows it is often advisable to build one or two partitions from floor to ceiling to prevent drafts. Fresh air can be admitted through muslin-screened windows opened on the side opposite to that from which the wind is blowing without causing drafts if all other sides of the building are tightly closed.

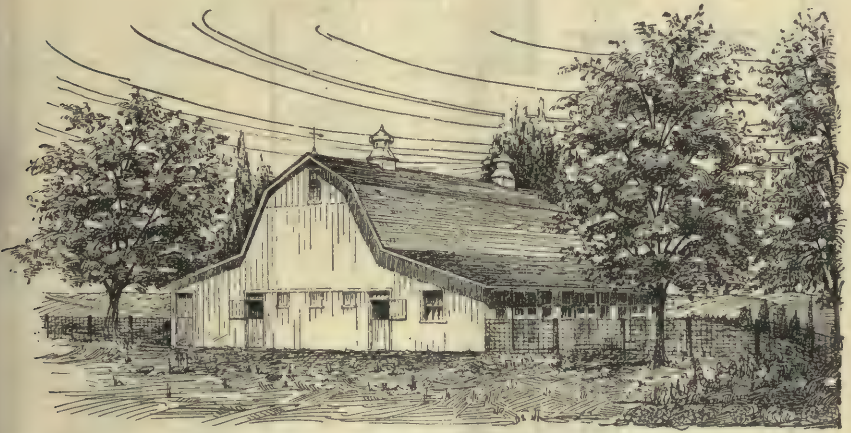

FIG. 5.—Combination horse, cattle, and sheep barn. In requesting plans and specifications for this building, mention subject No. 685–A3, serial Nos. 612 and 613.

In very cold sections, or where lambs are to arrive in the winter months, specially arranged outlets for foul air and inlets for fresh air will be necessary. Foul-air flues should extend from the ceiling with as few bends as possible to the roof. They should be of sufficient size and number to give 8 to 10 square inches for each sheep in the building. Fresh air may be admitted through arranged inlets near the floor line. Some attention is required to adjust such inlets to the variations in wind and temperature, and the same is true where windows are depended upon. There is no efficient automatic system of ventilating sheep buildings.

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[1] Farmers' Bulletin 438, "Hog Houses," contains directions for the placing of windows to secure the maximum of sunlight at any season and in any latitude.

FLOORS.

Level and well-drained clay-surfaced floors are satisfactory and economical. Sheep pack the surface very firmly, and if there is proper drainage the only objection to this floor is that it does not exclude rats. Concrete floors for alleys and feed rooms are necessary, but will seldom be called for in the pens.

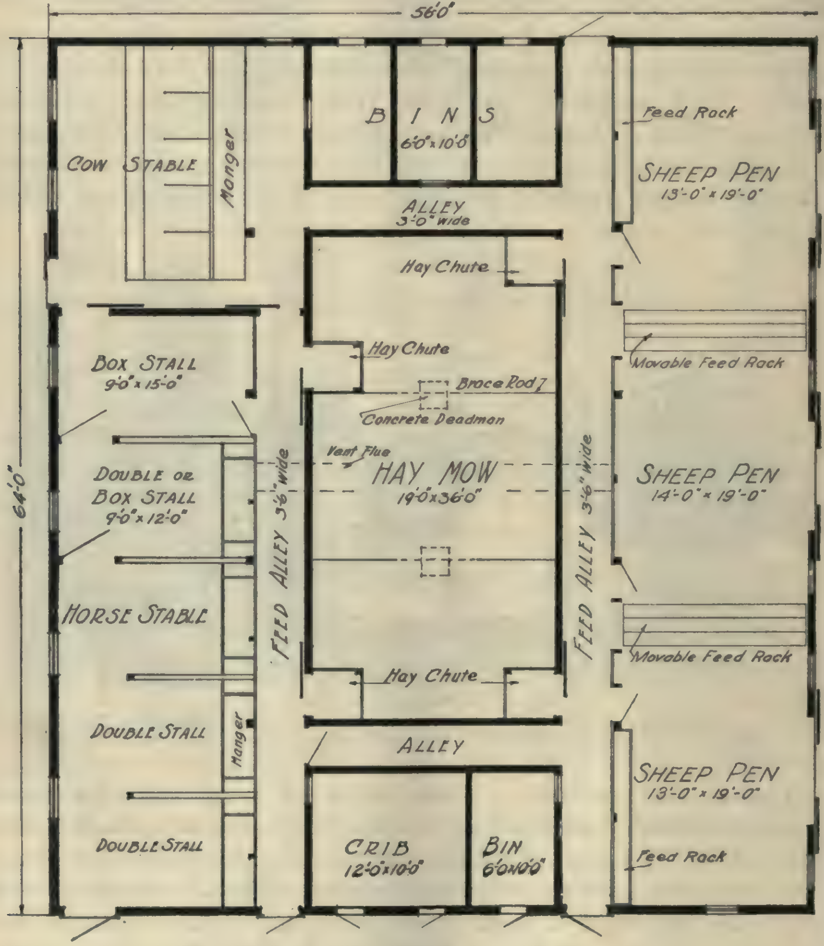

FIG. 6.—Floor plan of barn shown in figure 5.

ARRANGEMENT OF BUILDING.

The main features to be provided in the floor plan are minimum of waste space, convenience and ease in feeding and in cleaning the pens, and elimination of the need of moving or disturbing the sheep. Pen partitions should be movable. By using feed racks to make divisions in the pen space the size of the pens can be varied as needed,

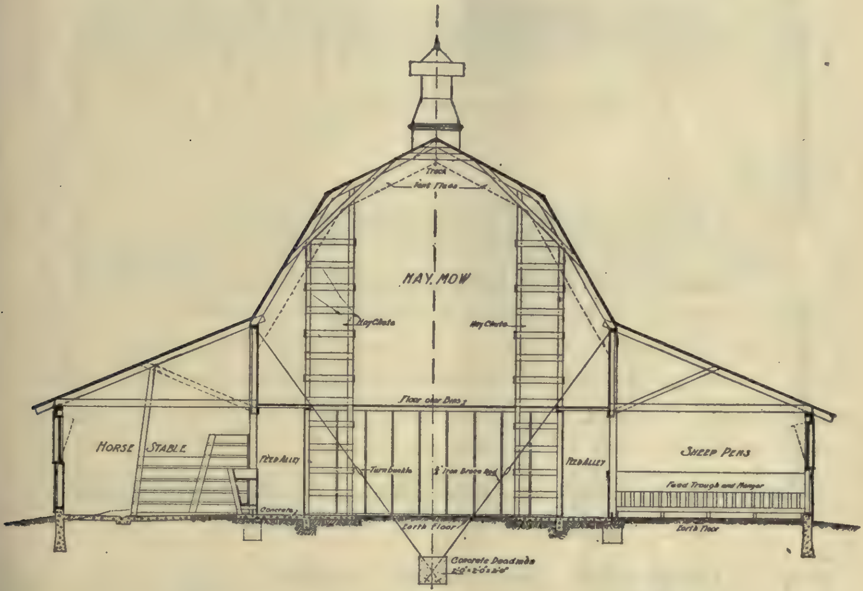

FIG. 7.—Cross section of barn shown in figure 5.

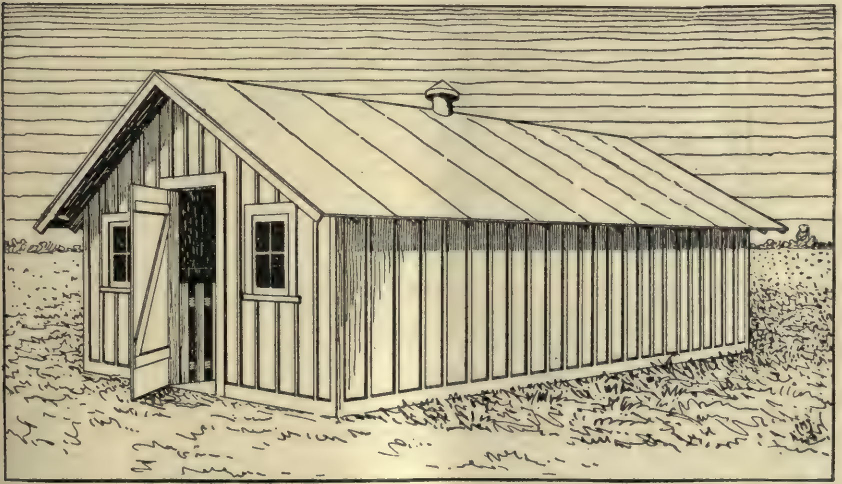

FIG. 8.—A closed sheep shed. In requesting building plans and specifications, mention 685-B2, serial 566.

and in special cases the racks can be removed to permit the use of the space for other stock.

A BARN FOR THE EXCLUSIVE USE OF SHEEP.

In figures 1, 2, 3, and 4 are shown a perspective view, floor plans, and cross sections of a building for the exclusive use of sheep, which is designed to meet the needs of those permanently engaged in sheep raising on a large scale. The eight large pens will each hold 20 ewes, allowing 12 square feet of floor space and 15 inches of rack space per ewe, and the small pen at the north end will accommodate 4 or 5 bucks. The partitions between the pens are formed by movable feed racks of the type shown in figures 15 and 16, so arranged

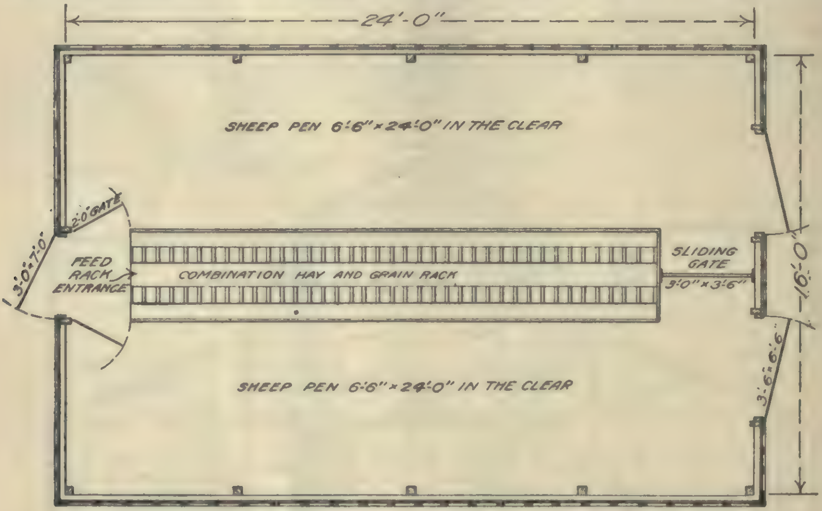
24'-0"
SHEEP PEN 6'-6"×24'-0" IN THE CLEAR
2'-0" GATE
3'-0"-7'-0"
FEED RACK ENTRANCE
COMBINATION HAY AND GRAIN RACK
SLIDING GATE
9'-0"×3'-6"
16'-0"
3'-6"-6'-6"
SHEEP PEN 6'-6"×24'-0" IN THE CLEAR

FIG. 9.—Floor plan of shed shown in figure 8.

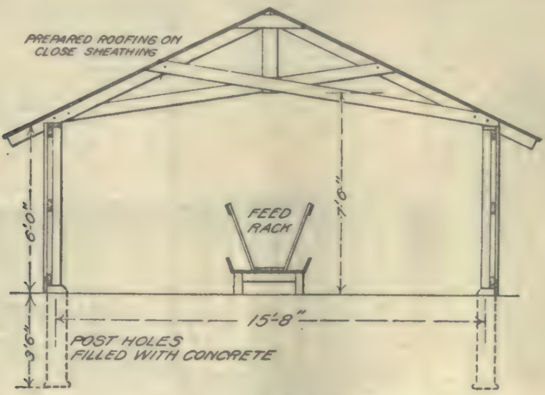
PREPARED ROOFING ON CLOSE SHEATHING
6'-0"
7'-6"
FEED RACK
3'-6"
15'-8"
POST HOLES FILLED WITH CONCRETE

FIG. 10.—Cross section of shed shown in figure 8.

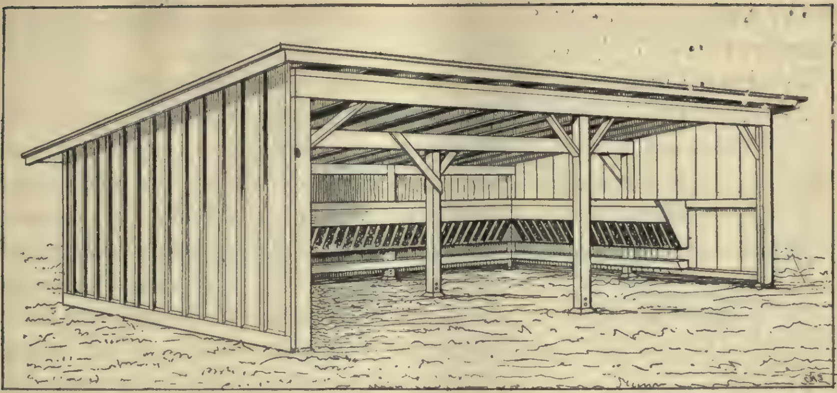

Fig. 11.—An open sheep shed. In requesting plans and specifications for this shed, mention subject 685–B2, serial 565.

that the attendant can walk down the center to distribute feed; and those next the alley are formed by wall racks such as are shown in figures 18 and 19. An advantage would be gained by having the movable racks which form the fronts of the pens made in 10-foot lengths, with a light 3-foot door hung on one end. This arrangement will allow wider latitude in the use of the double cross racks for dividing the pen space; it would permit the forming of pens 10, 20, or 30 feet in width. The door upon the end of the alley rack

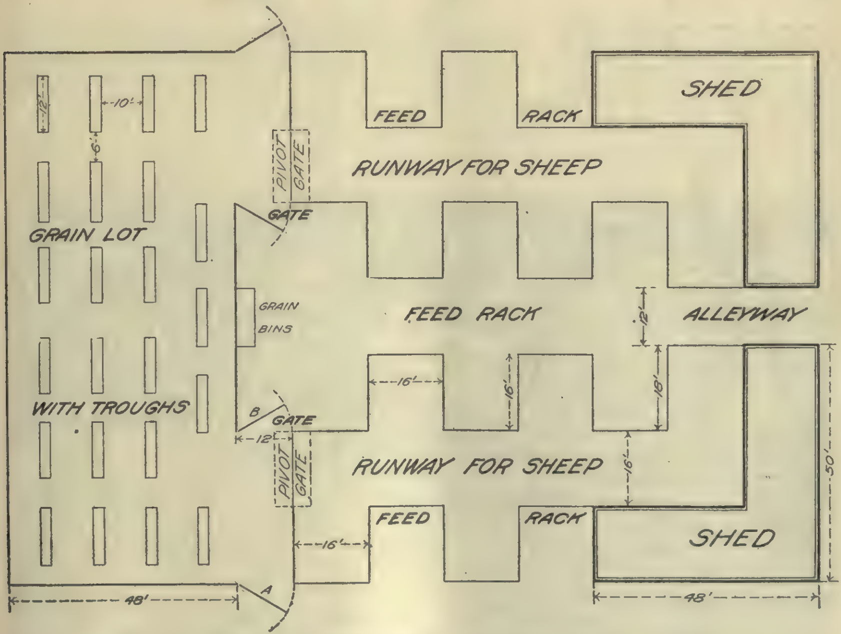

Fig. 12.—Plan of a feed lot for finishing lambs for market.

would always be where it was needed to fasten to the cross rack and close the pen.

This barn provides storage space for 55 tons of loose hay or straw in the mow and 1,100 bushels of grain in the storage room on the second floor. This is enough feed, except silage, to carry all the sheep that should be put into the barn, for a period of five months. The silo should have a capacity of 30 tons. Arrangements are made for filling the mow by horse fork and carrier, and for hoisting feed in bags with a block and tackle. Hay is thrown down through two chutes, each fitted with a sliding door at the bottom, and grain is delivered to the first floor through four spouts, each of which may carry a different mixture. The railing around the platform scale near the feed spouts should have gates arranged so that either sheep or feed may be weighed.

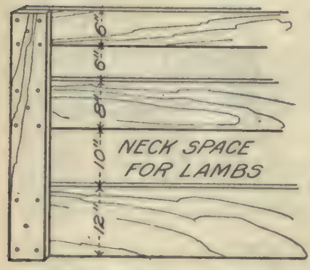

FIG. 13.—Section of a panel that may be used for fencing a lot and as a feed rack for sheep.

During the lambing season, which seldom lasts over six weeks, the detachable lambing pens, illustrated in figure 25, may be used. These have a great advantage over permanent lambing pens, since they can be folded up and put away when not in use.

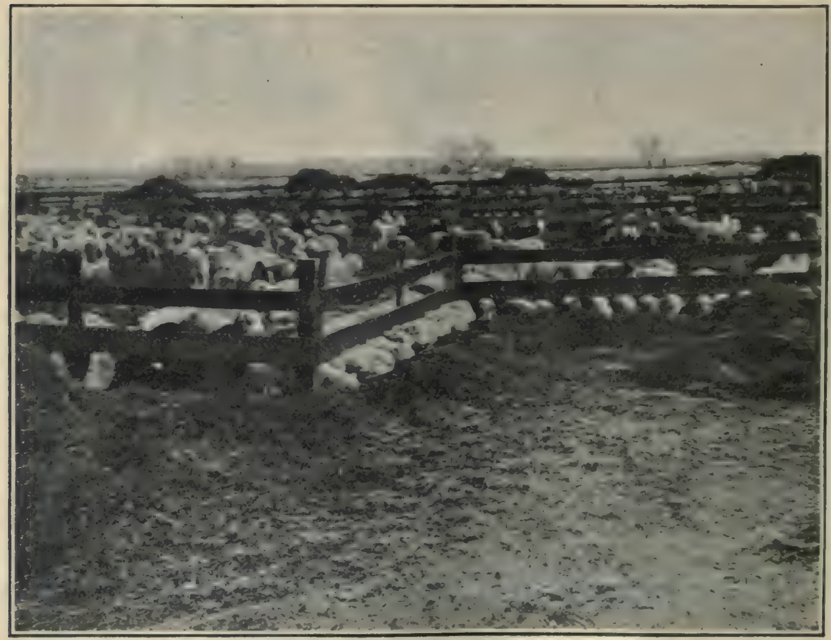

FIG. 14.—Illustrating the use of panel shown in figure 13.

The shepherd's room is equipped with a stove and medicine closet and may be used as a hospital for chilled lambs. With a room of this kind at the disposal of the shepherd, this barn may be considered as having all of the essentials for successful winter lambing.

With a larger silo, a supply of roughage stored outside the barn with which to refill the mow late in the fall, and a few extra feed racks set up in the lots, this barn could be used for feeding out two carloads of lambs in early winter before being needed for the breeding ewes.

The estimated cost of the barn proper, without feed racks, is $2,400. These figures are given only as a guide, however, as the actual cost may vary considerably from this amount, according to local prices of material and labor and the amount of farm labor that is used. The estimated cost of a 9 by 26 foot concrete silo of 30-ton capacity is $150, and for each additional ton $3.10 extra (Farmers' Bulletin 589).

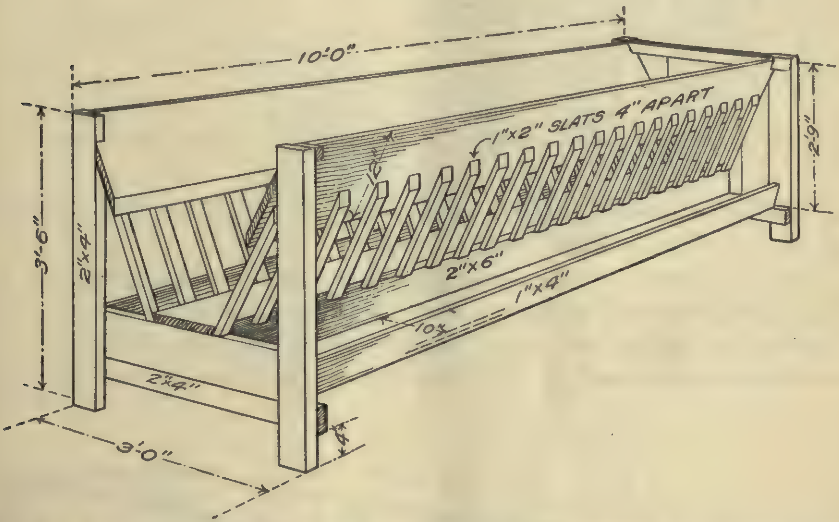

FIG. 15.—A combination hay and grain rack which may be entered by attendant when feeding grain.

A COMBINATION HORSE, CATTLE, AND SHEEP BARN.

Figures 5, 6, and 7 show a perspective view, floor plan, and cross section of a general barn intended for farms where all live stock is kept in a single building. This barn will accommodate 10 horses, 5 cows, and 63 sheep. In order that no kind of stock may be disturbed by the presence of another, and to prevent drafts through the building, the quarters for the horses, cows, and sheep are partitioned off, as shown by the heavy lines on the plan and cross section. The cow stable is ceiled on the inside of the studs to make it warmer and

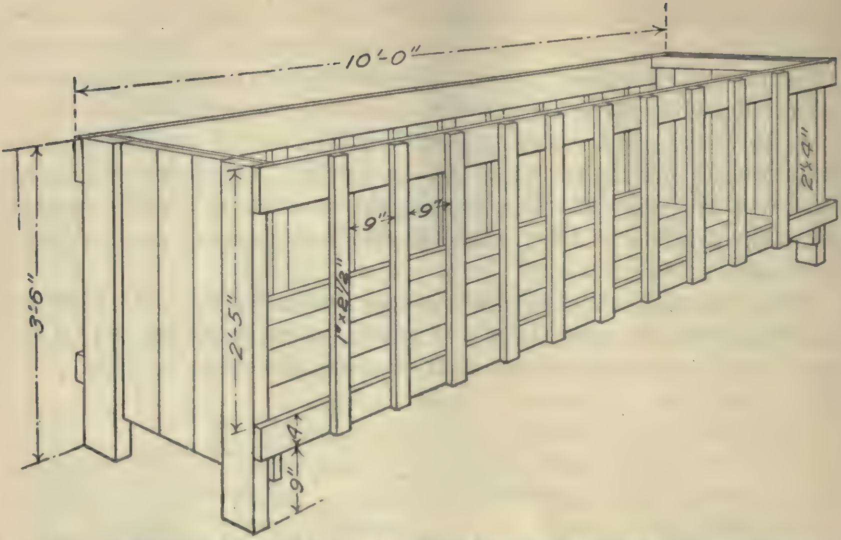

FIG. 16.—Combination hay and grain rack with bottom for feeding both roughage and grain.

to provide a smooth surface which will not collect dust, but the rest of the barn has a single wall.

The equipment for the sheep pens is the same as that discussed for the barn illustrated in figures 1 to 4, and similar doors, windows, and ventilation system are used. More window area per square foot of pen space is provided in this barn than in the other, because the par-

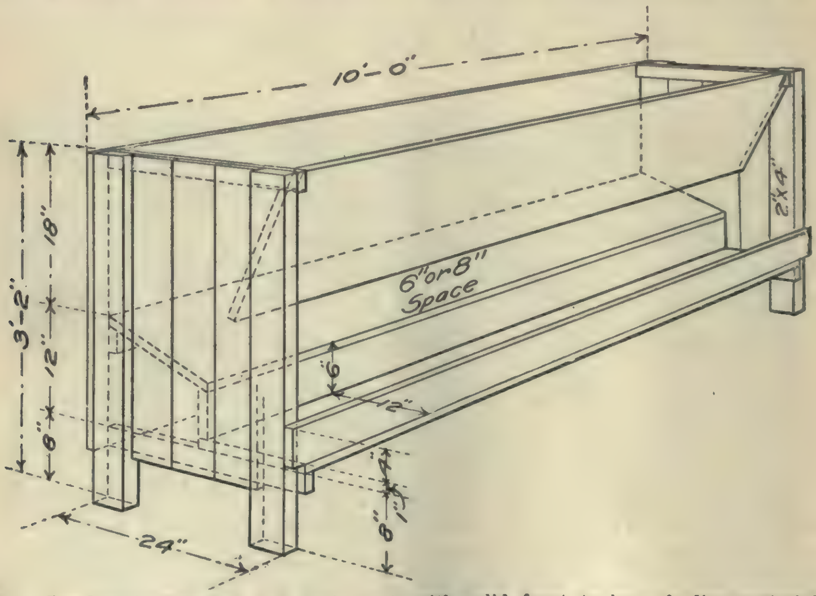

FIG. 17.—Combination hay and grain rack with solid front to keep feeding materials out of fleece.

titions prevent light from passing from one side of the building to the other, and the low eaves shade the windows part of the day. The hay mow, which has a capacity of 50 tons and is filled by a horse fork and carrier, occupies the entire central part of the building from the ground to the roof and also the space above the alleys and grain bins. It is reached through four hay chutes, placed to make feeding easy. The total capacity of the grain bins is 2,000 bushels, so that the barn has feed capacity enough to carry the stock on full feed for five months.

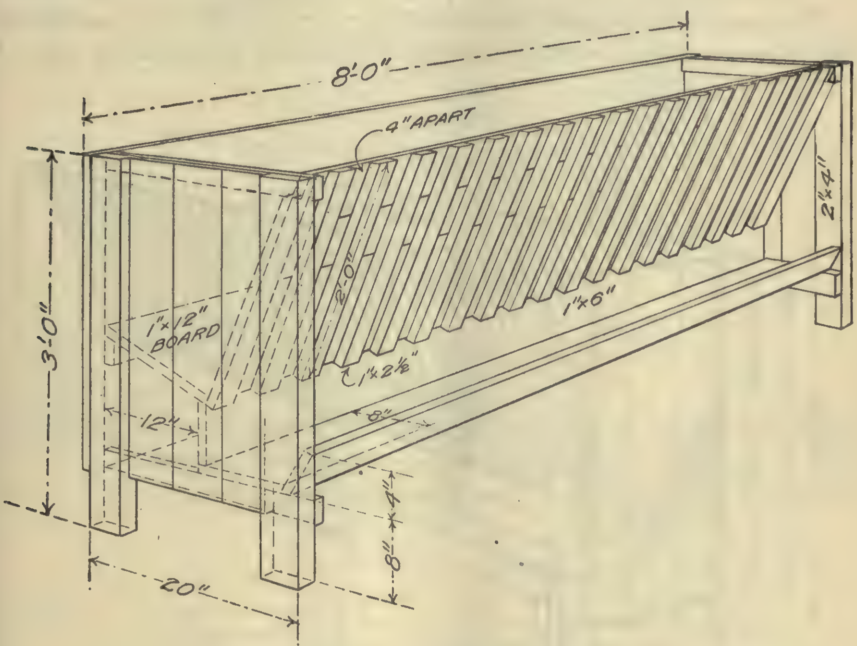

FIG. 18.—A stationary or wall hay and grain rack.

The estimated cost of this barn complete is $2,125, but this amount is intended only as a guide, the actual cost varying with local prices of material and labor and the amount of farm labor that is used.

A CLOSED SHEEP SHED.

Figures 8, 9, and 10 show a simple type of closed sheep shed which is especially adapted for farms on which the main barn has large feed capacity but not sufficient floor space for the live stock. Allowing 12 square feet of floor space per animal, this shed will hold 26 sheep, which gives a space at the rack of almost 17 inches each. One of the racks shown in figures 15 and 16 should be used in this shed, and the feeding should be done entirely from the walkway in the center so as to avoid disturbing the sheep. The large door at the end of the rack is intended for taking in feed, which must be stored in another building. The windows of this shed should be hung on center pivots to permit entrance of air through the full size of the window. The doors used by the sheep may be made in two parts, opening outward independently. The upper half should be hinged at its top and counterbalanced by a weight connected to it by a light wire cable passing through a pulley at the side of the shed and another on the eave. A stay rod is needed to hold the door firmly when it is partly open. The doors, windows, and roof ventilator always will furnish good ventilation if properly adjusted.

This shed affords good protection for sheep under any conditions and may be used for winter lambing if it is made 20 feet wide instead of 16, so that as many detachable lambing pens as are needed may be set up next the wall and still leave room at the rack for the other ewes. The estimated cost of this shed is $140.

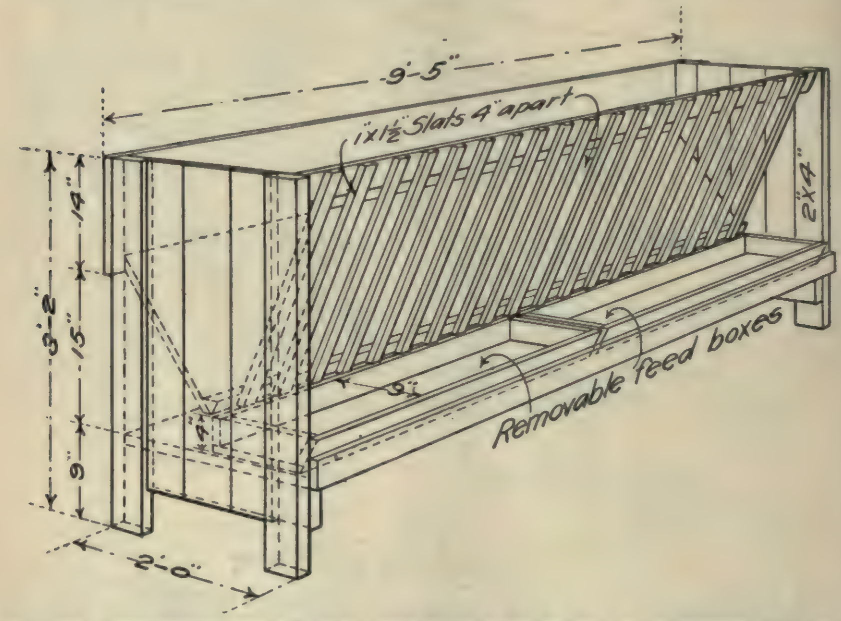

FIG. 19.—Combination hay and grain rack, with grain troughs so constructed that they may be pulled to back of rack and grain placed in them without entering the pen.

AN OPEN SHEEP SHED.

Figure 11 shows a shed 16 feet wide by 24 feet long, open on the south side and having feed racks of the type shown in figure 18 or figure 20 along the other three sides. This shed will shelter 30 mature sheep, allowing 12 square feet of floor space per animal.

When sheds of this type are well protected by trees they are satisfactory for mature sheep in almost any section. They do not furnish sufficient protection for winter lambing in a cold climate, but may be used profitably for this purpose in many parts of the South. The estimated cost of this shed complete is $90.

A FEED LOT FOR FATTENING LAMBS.

Figure 12 shows the plan of a feed lot designed to care for 400 fattening lambs. With certain modifications it is planned after the lots successfully used in Colorado and other western States. This plan provides for running the number of lambs mentioned in two pens. The panels which divide the pens also make the racks for feeding hay. These panels are built as shown in figures 13 and 14. They should be made of strong material and securely attached to posts at the corners and centers.

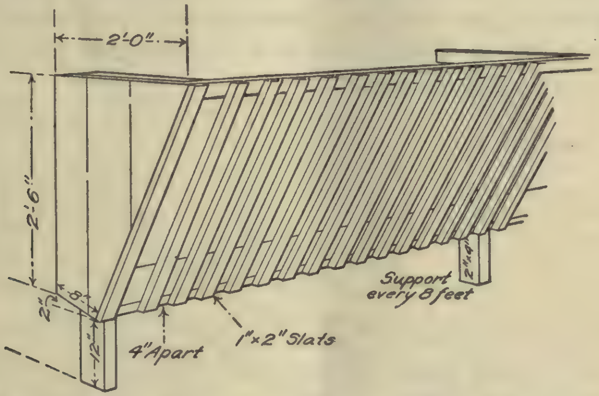

FIG. 20.—Stationary or wall rack without provision for feeding grain.

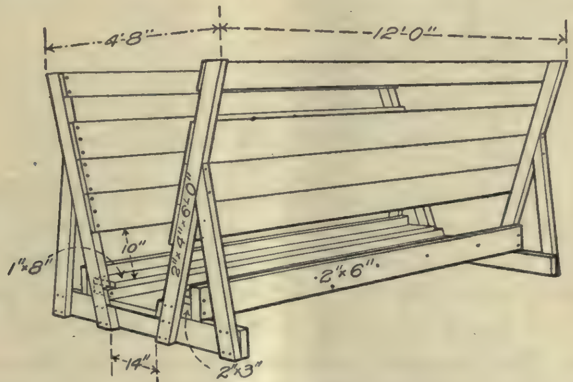

FIG. 21.—The self-feeder hay rack.

In distributing hay to these racks, a wagon may be driven through the gates (indicated at A and B) down through the main feed racks and out between the two sheds. Grain can also be unloaded at the grain bin direct from the wagon.

If desired the self-feeder hay rack described in figure 21 can be substituted for the "fence" rack. If this is done, the feed lot may be inclosed with a straight fence rather than the irregular panels used for feeding purposes.

A sufficient number of grain troughs is provided in the grain lot for feeding at one time all of the sheep included in one of the pens. The pivot gate shown in figure 12 is used on the same plan as a water gate. The projecting ends of the horizontal top piece are secured by strap iron at the tops of the posts supporting them. The gate is opened by means of a vertical narrow board fastened at one end and projecting above the top. After the lambs have learned to eat grain they are likely to crowd toward the grain yard. When the troughs are filled the gate is opened by swinging the bottom away from the lambs, allowing them to pass under. This opens the full width of the gate at once and avoids any trouble through the lambs crowding against the gate.

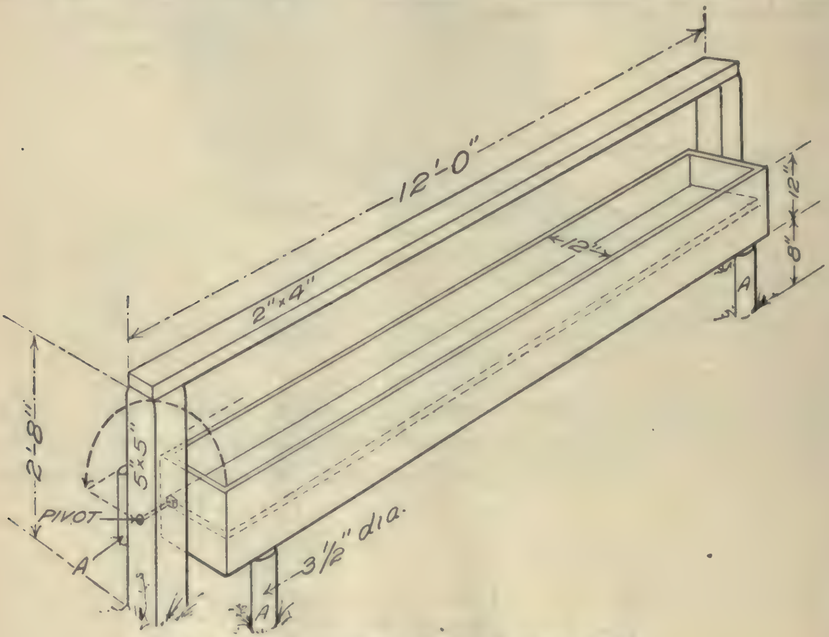

FIG. 22.—A reversible stationary grain trough.

FEED RACKS.

COMBINATION HAY AND GRAIN RACKS.

Combination hay and grain racks are probably the most convenient for feeding small lots of sheep. The open-end rack shown in figure 15

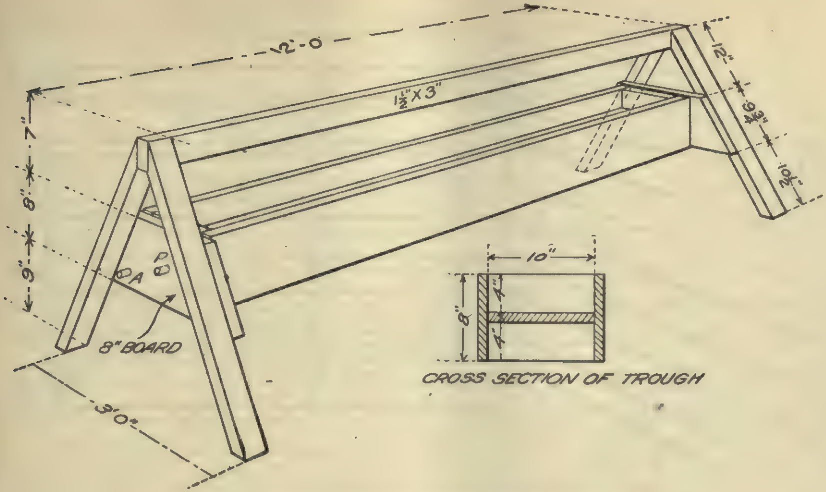

Fig. 23.—A reversible movable grain trough.

is for use in barns where feeding is done by passing directly from the alley to the rack, thus obviating the difficulties which follow from entering pens filled with sheep. Figure 16 shows a rack that is sometimes preferred in which hay and grain are fed from the same bottom. This rack, however, requires the feeding of hay and grain at different times.

The fleeces of sheep may be kept comparatively free from chaff or other feeding material by exercising care in distributing the feed.

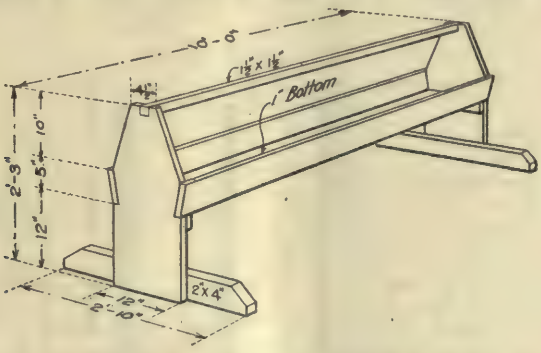

Fig. 24.—A light movable trough for feeding grain and roots.

Some shepherds prefer a rack with closed sides instead of slats; such a rack requires that the hay be eaten through an opening at the bottom as shown in figure 17.

A stationary rack which may be built against a wall or a partition (fig. 18) effects a considerable saving in floor space, but does not permit the feeding of grain without entering the sheep pen. In a

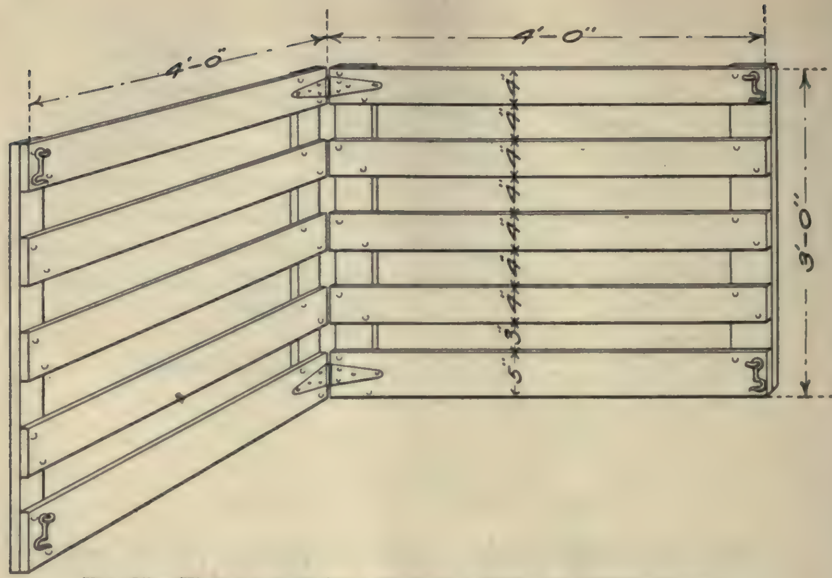

FIG. 25.—Hinged panels for temporary lambing or claiming pens.

rack such as shown in figure 19 provision can be made for sliding the grain boxes through below the hay rack and filling them from the alley outside.

HAY RACKS.

The wall rack shown in figure 20 is very useful in connection with open sheds. This rack is for hay only and may be constructed very cheaply.

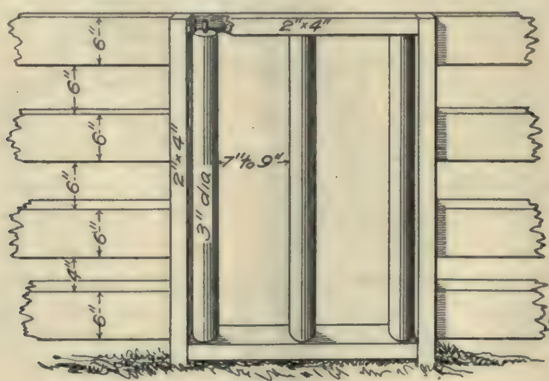

FIG. 26.—Lamb creep with rollers for uprights.

The self-feeder rack for hay shown in figure 21 is commonly used where very large numbers of sheep are fed. In building this type of rack care should be taken to insure ample width between the sides

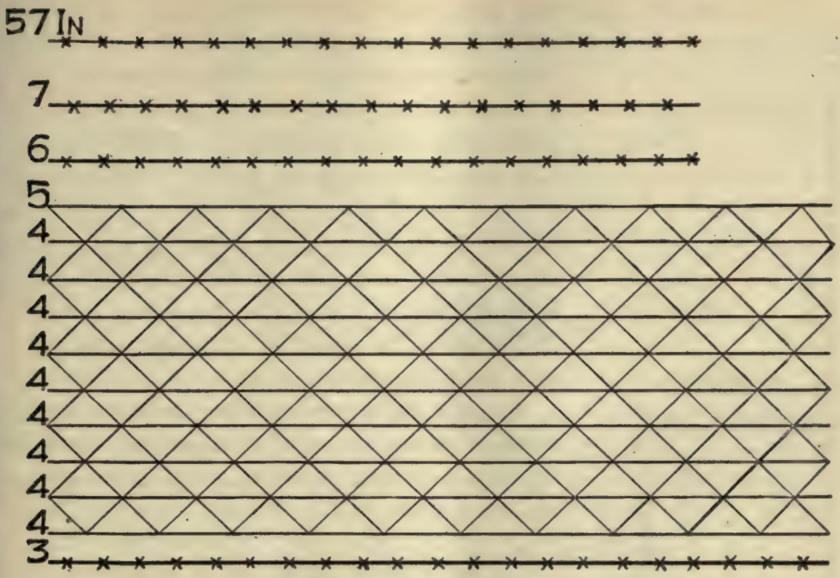

FIG. 27.—A dog-proof fence.

at the bottom and for the side openings at which the sheep feed. This will remove the necessity for keeping the hay pushed down to the lower openings.

GRAIN TROUGHS.

Figure 22 shows a stationary reversible grain trough largely used in outdoor lamb-feeding yards in the West. A single board forms the bottom for each trough. To clean the trough it is only necessary to turn it over. The posts to which this trough is attached should

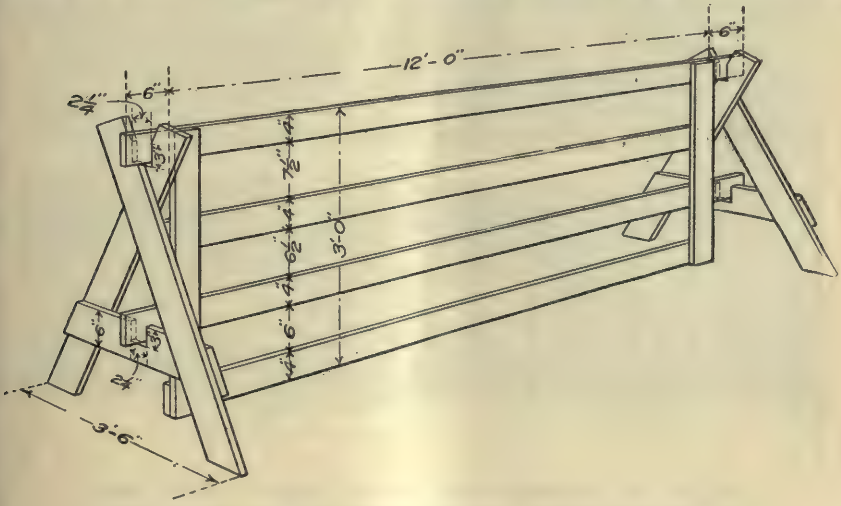

FIG. 28.—Panel and braces for making a portable sheep fence.

be firmly set to avoid being misplaced by the crowding of the sheep. The pivot upon which the trough turns is placed at the left of the center of the end piece. This brings the wide or heavier side of the trough always upon the peg placed at either side to hold it in position.

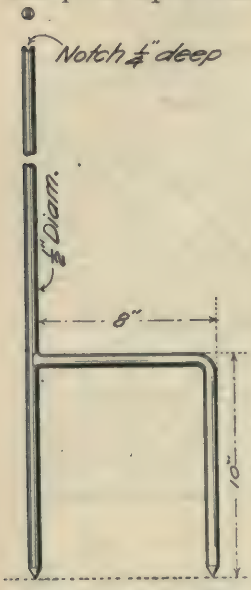

FIG. 29.—The iron standard which is successfully used at the Illinois Agricultural Experiment Station as a support for holding woven-wire fencing, in constructing temporary sheep fences.

A movable trough of this type is shown in figure 23. This trough is not so readily reversed as the stationary style, as a peg must be withdrawn to permit turning the trough and afterwards inserted to keep it in position. It is useful for small lots of sheep that are to be fed outdoors.

Figure 24 shows a simpler and lighter type of grain trough. Danger of upsetting can be overcome by giving ample length to the cross footpieces.

LAMBING PENS AND CREEPS.

The detachable lambing pen previously referred to for use at lambing time is shown in figure 25. Two panels are hinged together and furnished with hooks to fasten them to the wall or to other panels. The first pen is formed by placing the pair of hinged panels at right angles to each other in a corner of the pen and fastening them to the walls. Other pens are added as needed, one end being hooked to the corner of the last pen at one free end and to the wall at the other end. The figure shows panels for making a pen 4 by 4 feet, but a 3 by 4 foot pen can be used quite satisfactorily with ewes of average size. After lambing the panels can be removed and stored until the next season.

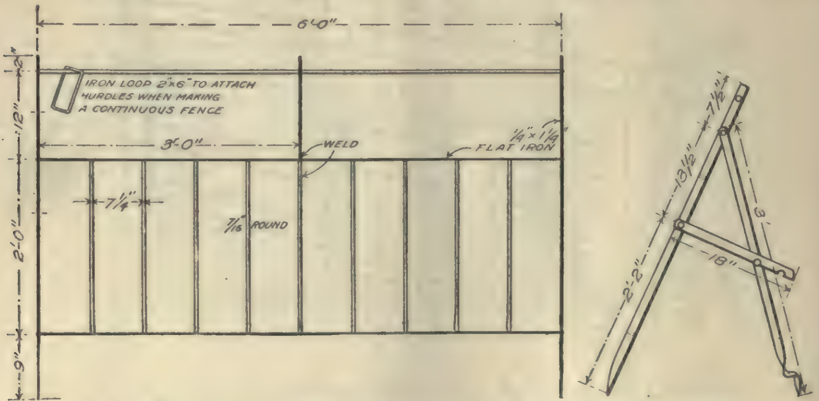

FIG. 30.—An iron hurdle used in close grazing of forage crops.

It is usually desirable to feed grain to young lambs while they are still suckling. For this purpose a "creep" which will admit the lambs and exclude the older sheep is necessary. This may be arranged by leaving some of the lambing panels in position after having had the side facing the main pen equipped with a 12-inch opening that can be closed with a sliding board. In large flocks a special small pen can be arranged for the lambs' feed troughs. Upright slats, or preferably rollers, as shown in figure 26, placed from 9 to 12 inches apart admit the lambs.

FENCING AND HURDLES.

For inclosing sheep pastures and lots a fence that will exclude dogs should be used. A less expensive fence would suffice for the sheep themselves, though a flock may prove very troublesome if kept under a poor fence that permits them to get into adjoining fields, thus forming the habit of breaking out. The dog-proof fence shown in figure 27 is 57 inches high; the posts are 7½ feet long, set 2½ feet in the ground. Close to the ground is a tightly stretched barb wire, next to which is a 36-inch woven-wire fence with 4-inch mesh, and above this 3 strands of barbed wire. Where coyotes or other animals may dig under the fence the barbed wire near the ground should be placed

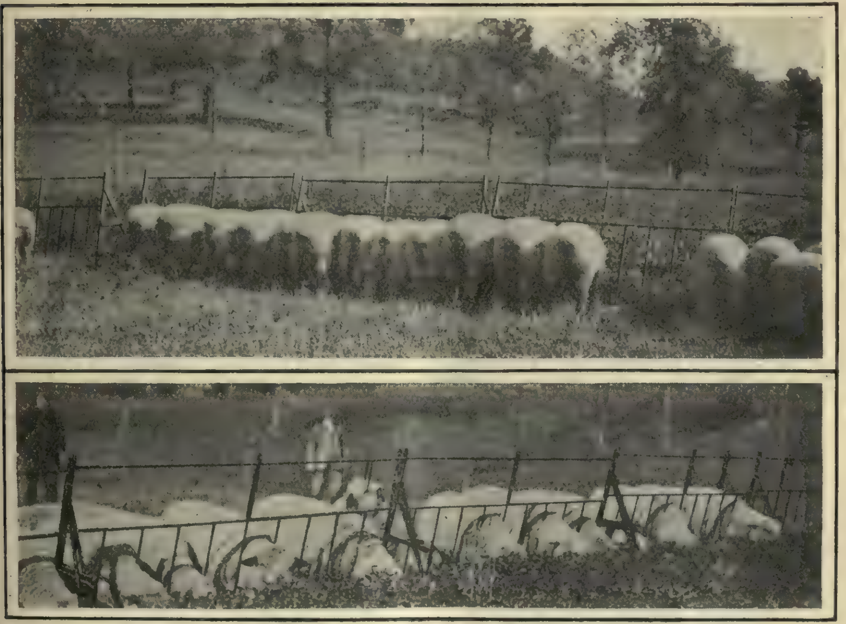

FIG. 31.—Illustrating the use of the iron hurdle shown in fig. 30.

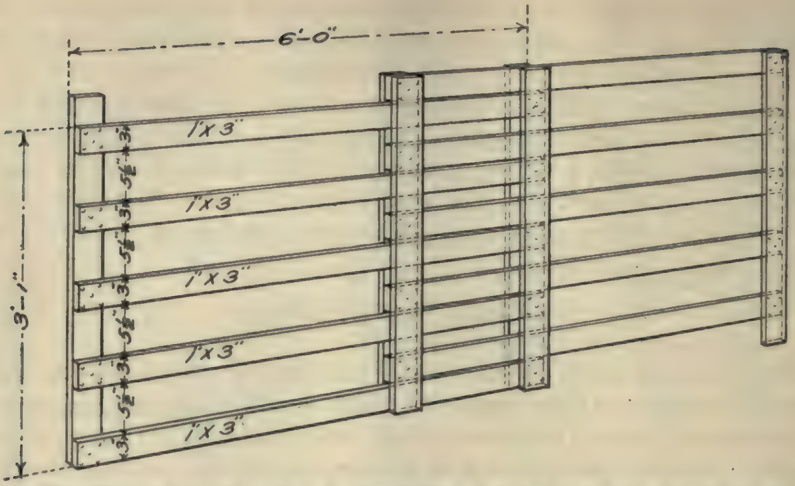

FIG. 32.—Extension hurdle. May be closed up to 6 feet 4 inches or extended to 11 feet 4 inches.

on the outside of the posts and the woven wire and higher barbed wires on the inside.

Temporary pens, lots, or small pastures can be inclosed by the portable hurdles, such as are shown in figure 28. In this hurdle the top board is notched about 4 inches from each end to fit into the

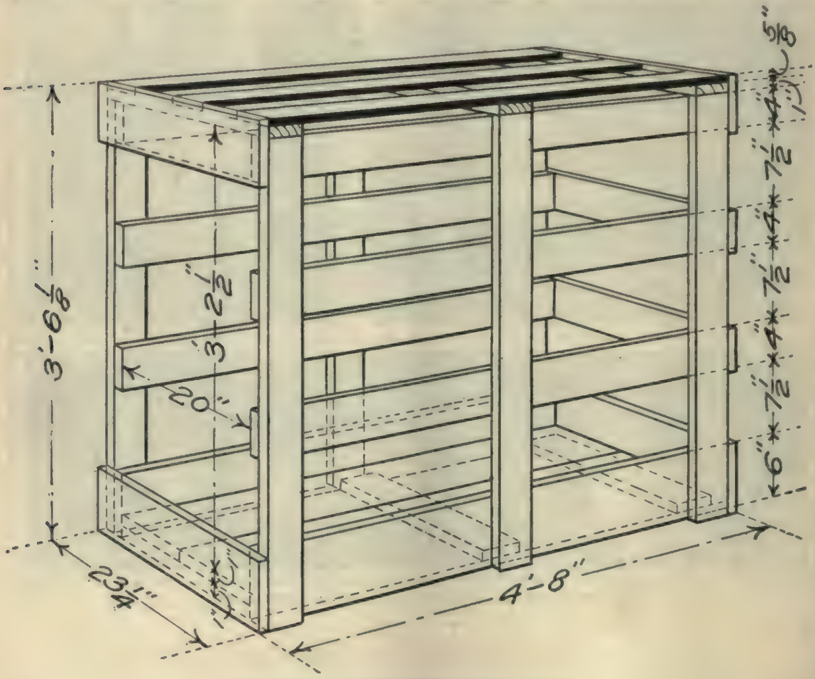

FIG. 33.—Light-weight sheep crate.

notch where the end pieces cross. Through the end of this top board a nail should be driven, otherwise the piece outside the notch will break off and cause the hurdles to work endways in their supports.

The hurdle just described can be used for fencing off parts of forage-crop pastures, though ordinarily woven-wire fencing that can be rolled up and used wherever needed is more satisfactory for field use. Woven wire used for this purpose can be stretched from permanent solid posts and supported at intervals by light sharpened posts stapled to the wire. For this purpose the iron standard shown in figure 29, which is in use at the Illinois Experiment Station, is a valuable piece of equipment. The upper end of the iron is passed through the lower wires and has a groove to hold the top wire in position. The post is set with the double foot at right angles to the direction of the fence.

Many British shepherds and a few in America use a hurdle of the type shown in figure 30 when grazing sheep upon rape or other forage. These hurdles are made of iron and permit the lambs to pass through and make use of the better grazing. They are moved forward when the older sheep have eaten all the forage behind them. One or two extension hurdles, such as the one shown in figure 32, are very useful in the sheep barn where it is desired to form a temporary pen to close an alleyway or to close a doorway without excluding the air. A light frame about 10 feet long with chicken wire 30 inches wide stretched over it is convenient for use in moving sheep around pens or holding a small lot in a corner of a field or pen.

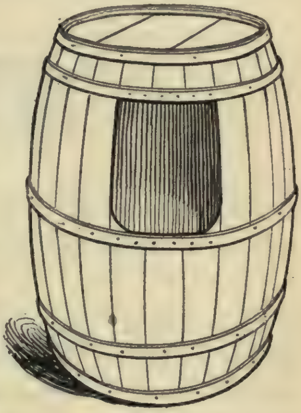

FIG. 34.—The barrel water trough.

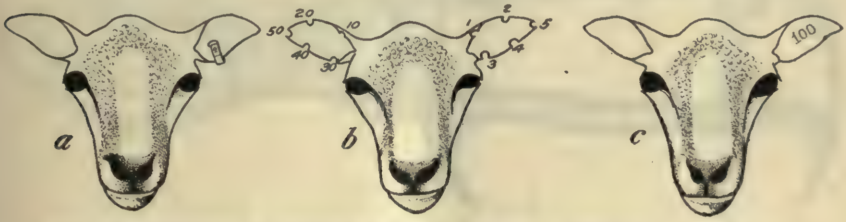

FIG. 35.—Methods of marking sheep: *a*, label; *b*, notching; *c*, tattooing.

MISCELLANEOUS EQUIPMENT.

DIPPING VATS.

Full descriptions of various styles of dipping vats and directions for the construction of permanent types are contained in Farmers'

Bulletin 713, obtainable from the Department of Agriculture, Washington, D. C.

SHIPPING CRATES.

The crate shown in figure 33, when made of well-seasoned pine, is amply strong and weighs only 25 pounds. Hay for feeding while in transit can be placed between the crate and a gunny sack tacked on the outside of the front end.

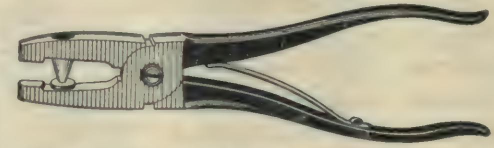

FIG. 36.—Punch used for inserting ear labels. Can also be used for notching.

WATERING TROUGHS.

If stationary troughs of wood or concrete are used they should be easily accessible to permit frequent cleaning. On account of the comparatively small amount of water consumed by sheep in winter an open half barrel set in the pen near the door is quite satisfactory, as it can readily be removed for cleaning or when the divisions of the pens are changed. The whole barrel with the opening in the side shown in figure 34 is serviceable in pens or lots, but allows only one sheep to drink at a time. It can be used where sheep have continuous access to it. A float valve connected with a water-supply pipe is protected in this device and the top prevents dirt or chaff from getting into the water. A removable top can be used if the barrel is to be filled by the use of a pail.

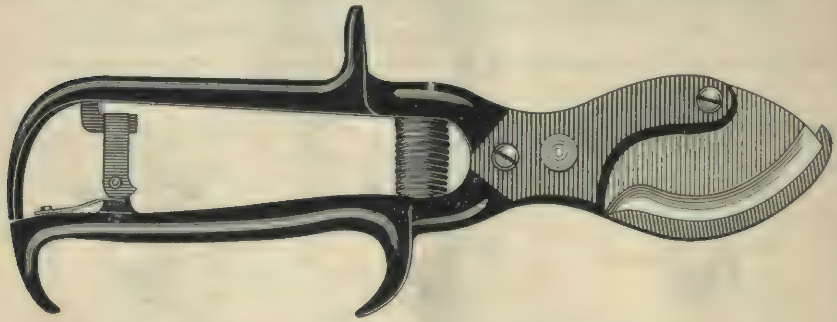

FIG. 37.—Ordinary pruning shears for trimming feet of sheep.

EAR LABELS AND TOE CLIPPERS.

When individual records are kept lambs must be marked soon after birth. The ordinary metal labels on the market are inserted with the punch shown in figure 36. One of the labels in position is shown in *a*, figure 35. The same punch can be used for notching the ears to number lambs according to the plan shown in *b*, figure 35. This plan permits numbering up to 99 without requiring more than two notches in the same ear. The tattoo numbers shown in *c*, figure 35, are the surest means of numbering or identification. Special holders and metal dies for inserting these numbers are obtainable from dealers in supplies.

A pair of ordinary pruning shears such as are shown in figure 37 are used in trimming the feet when sheep are not traveling enough to keep the horn of the hoofs worn down to natural shape.

SHEARS AND SHEARING MACHINES.

Well-sharpened sheep shears should always be at hand for trimming fleeces and removing tags. For shearing the sheep in spring one of the hand-power machines on the market should be used for medium-sized flocks. For large farm flocks two machine outfits with engine power are economical, as they are not very high in price considering the speed and superiority of the machine shearing over blade or hand shearing.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO SHEEP RAISING.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Breeds of Sheep for the Farm. (Farmers' Bulletin 576.)
The Sheep Killing Dog. (Farmers' Bulletin 652.)
Sheep Scab. (Farmers' Bulletin 713.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

The Management of Sheep on the Farm. (Department Bulletin 20.) Price, 10 cents.
Domestic Breeds of Sheep in America. (Department Bulletin 94.) Price, 25 cents.
The Wool Grower and the Wool Trade. (Department Bulletin 206.) Price, 15 cents.
Features of the Sheep Industries of United States, New Zealand, and Australia Compared. (Department Bulletin 313.) Price, 10 cents.
Our Present Knowledge of the Distribution and Importance of Some Parasitic Diseases of Sheep and Cattle in the United States. (Bureau of Animal Industry Circular 193.) Price, 5 cents.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

THE PRODUCTION OF BABY BEEF

S. H. RAY
Animal Husbandry Division

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LIVE-STOCK markets during recent years have experienced a constantly growing demand for well-fattened beef animals weighing from 900 to 1,200 pounds. This has been due to the increasing demand by beef consumers for light-weight, high-grade cuts. Such a demand must necessarily be supplied by well-finished animals from 14 to 20 months old, carrying a large percentage of the blood of one of the early-maturing beef breeds, usually that of the Hereford, Aberdeen-Angus, or Shorthorn. To distinguish them from animals of other beef classes, these yearlings have come to be designated as baby beeves. The preparation for market of this class of beeves requires more skill than is necessary in the production of animals marketed at more mature ages, since the growth in the latter is made largely on the cheaper roughages of the farm.

With the growing scarcity of feeder cattle and the advance in value of farm lands, the baby-beef industry is of increasing importance and is receiving the attention of farmers in all live-stock sections of the country. This bulletin deals with various phases of the production of baby beef for market.

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CONTENTS.

	Page.		Page.
Tendency toward early marketing of beef animals	3	Type of cows to use	7
Why baby-beef feeding is profitable	3	Type of bulls to be used	8
When production of baby beef is not advisable	4	Type of calves suitable for baby beef	9
Breeds suitable for baby-beef production	7	Management and feeding of breeding herd	10
		Calf management and feeding	17
		Hogs following baby beeves	22

TENDENCY TOWARD EARLY MARKETING OF BEEF ANIMALS.

FEEDERS at the present time show an increasing tendency toward finishing off their beef cattle at younger ages. In general this tendency is created by two causes: First, consumers are demanding small, high-quality cuts of meat; second, the cost of producing beef, due to advance in land values, feeds, labor, and taxes, has increased to such an extent that feeders and breeders can seldom hold their cattle to advanced ages at a profit. General conditions in the past few years have indicated that no class of beef yet produced more nearly fulfills the requirements of both producer and consumer than baby beef, and the feeding of baby beeves has been increasing in popularity.

In the early days of the cattle industry steers were kept on the range until from 3 to 5 years of age. The use of better bulls with consequent improvement in quality and early maturity of market cattle, together with heavier grain feeding, has made it possible to put just as much flesh on the animals by the time they are from 10 to 20 months of age. With improvements in breeding and in feed-lot methods heavier cattle with more quality may in time be put on the market at even a younger age. The precise age at which steers should be marketed depends upon several conditions, and the individual feeder must necessarily answer this question for himself. It is intended, however, in the following pages to discuss rather briefly the conditions governing this as well as other phases of baby-beef production in such a manner as to help the feeder to solve such problems.

WHY BABY-BEEF FEEDING IS PROFITABLE.

In a general way the following are the advantages in favor of finishing cattle at younger ages rather than waiting an additional year or two before they are placed upon the market.

1. Young cattle make better gains than older cattle on the same quantity of feed. Yearlings can make 25 to 40 per cent more gain than mature cattle on the same feed. The quantity of feed necessary to make 100 pounds of gain increases with the age of the animal.

2. The herd of cattle on hand at any one time is smaller, since the breeder selling cattle as yearlings no longer has steers 2 or 3 years old on his farm. The surplus feed and pasture which becomes available when the cattle are sold before 2 years of age may be used for maintaining a larger breeding herd, and this provides for the production of a larger number of calves. By feeding calves as baby beef, the money invested can be turned over in 18 months or less.

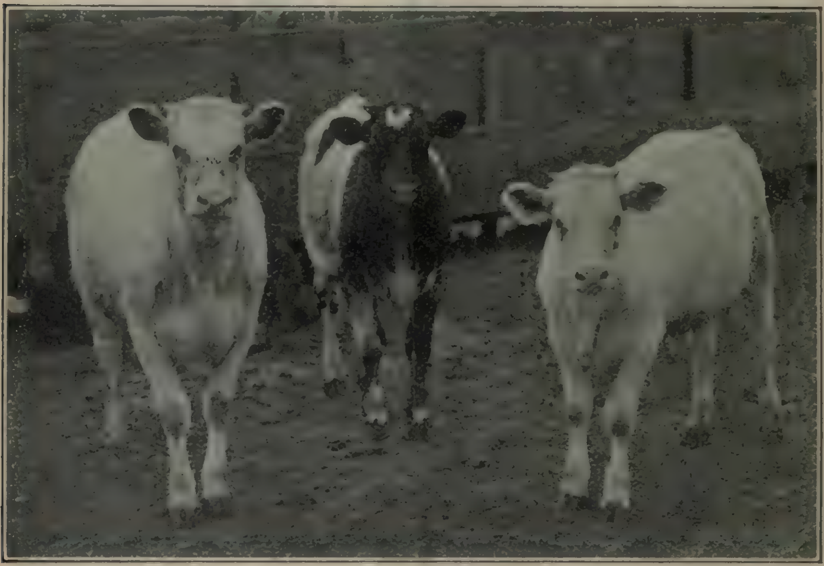

FIG. 1.—This trio of calves illustrates the type approved by the producer of baby beef. They have been kept growing and have not been allowed to lose their milk bloom.

3. Open heifers when finished as baby beef at 900 to 950 pounds sell as well as steers. As a general rule it is better to dispose of them at such weights, although frequently well-finished heifers weighing up to 1,050 pounds are not discriminated against: When they are over 2 years of age, however, they seldom sell as well as steers, because heifers and cows carry a great deal of bunched internal fat, which makes them less desirable on the market.

4. Well-finished beeves when fattened for market under 2 years of age offer greater choice in the matter of selecting the date of marketing. The yearling of high quality can be fed either a somewhat shorter or longer time than first planned without any material change in "bloom" or finish (fig. 1). This is a decided advantage if the market is unsteady or weak. However, if market demand is steady,

as is usually the case with this type of beef, the good feeder will endeavor to market his animals when their bloom or finish is at its best.

5. The average consumer prefers the size and quality of the cuts which are obtained from the carcass of a well-bred highly finished yearling. In addition to high quality, thickness in steaks and other cuts of beef is desired by the consumer, and these can be produced more economically in the well-matured yearling than in any other class of beef animal. (Fig. 2.)

6. Markets are paying a premium for this type of beef, and the market for baby beef in recent years has been more stable than for any other class of cattle. During the last few years this class of beef has practically had a market of its own, and until packing centers can command a larger supply relatively greater stability in prices for fat yearling beef may prevail. Prime baby beef usually commands a price equal to that of the highest grade of mature fat cattle.

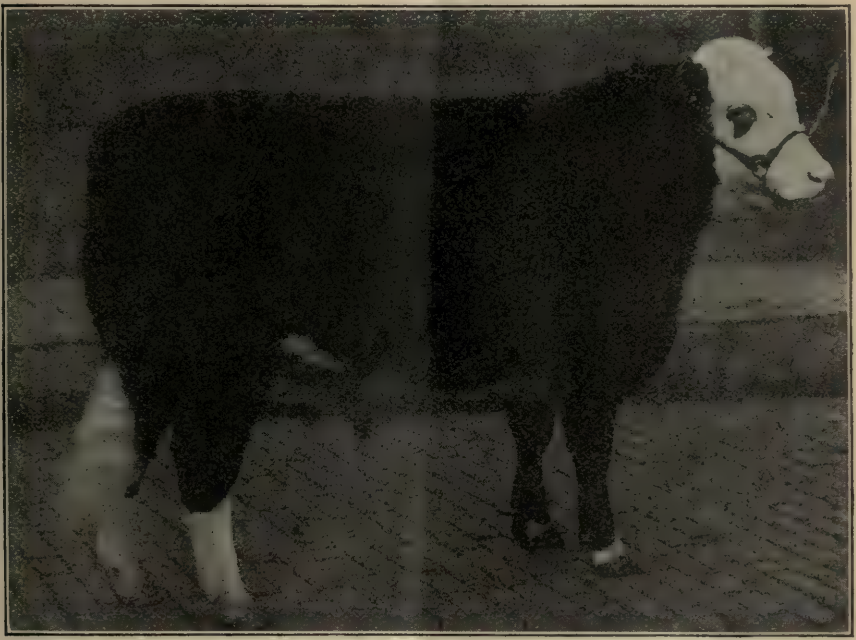

FIG. 2.—A prime baby beef. Note his depth, thickness, quality, and finish. The animal is a crossbreed—Hereford-Shorthorn.

WHEN PRODUCTION OF BABY BEEF IS NOT ADVISABLE.

While the most favorable age for the marketing of the better types of beef cattle is under 2 years, the system can not be followed with all types of beef cattle or by all feeders. Some of the conditions under which the finishing of cattle at this age is not advisable may be outlined as follows:

1. The farmer who is inexperienced in methods of beef production is not qualified to take up baby-beef production, but should take up one of the simpler systems. A system which may be adopted by such a feeder is that of the breeding up of a grade herd through the use of pure-bred bulls. For the first three or five years the produce of such breeding can be sold either as feeders at the yearling or 2-year-old age, or kept on a light ration or on grass until 2 years of age, when they can be fattened for market. (See fig. 3.) By beginning in this manner the farmer gains experience and at the same time builds up a herd which in a few years will be good enough for the production of baby beef. In many cases lack of experience on the part of the feeder can be offset to a large extent if he will take advantage of the service and advice which are available for him through his State agricultural college.

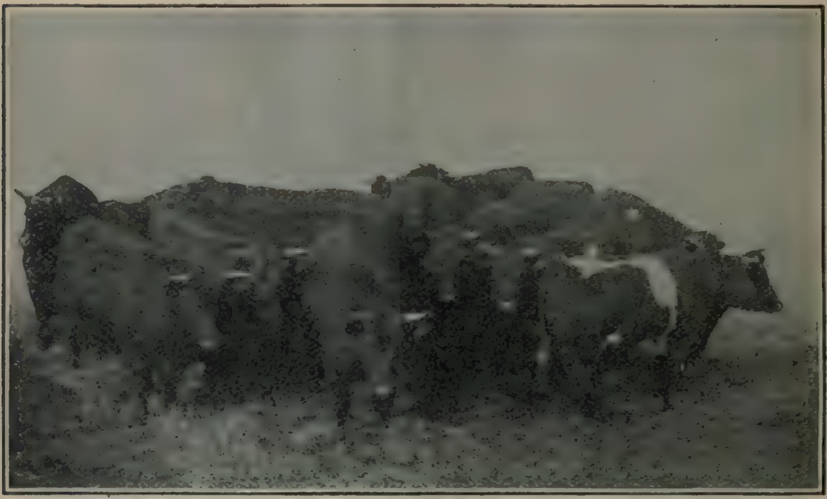

FIG. 3.—Heavy baby beeves. They are older than most baby beeves of to-day, but show quality, uniformity, and finish.

2. Cattle with poor beef form or of poor quality are too slow in maturing and will not take on the fat and finish which is essential with baby beef. If the feeder decides that his calves are not good enough to sell as baby beef, he should either finish them off on somewhat coarser feeds for a later market or carry them until they are older before fattening them.

3. When the available feed consists chiefly of roughage, no attempt should be made to feed out calves as baby beef, since they require a larger proportion of grain and other concentrated feeds in their ration than more mature cattle. To produce baby beef grain must be fed

in considerable quantities from the time of weaning or before to the time of marketing, while more mature cattle may be fed largely or wholly upon roughages during the early part of the feeding period.

BREEDS SUITABLE FOR BABY-BEEF PRODUCTION.

The strictly beef breeds of the United States are the Shorthorn, Hereford, Aberdeen-Angus, Galloway, Polled Durham, and Polled Hereford. Each of the breeds mentioned has its points of excellence, and the matter of making a selection, while depending somewhat upon local conditions, rests largely upon the personal preference of the breeder. The problem of selecting the individual animals after the breed has been determined is really of greater importance than the selection of the breed itself.

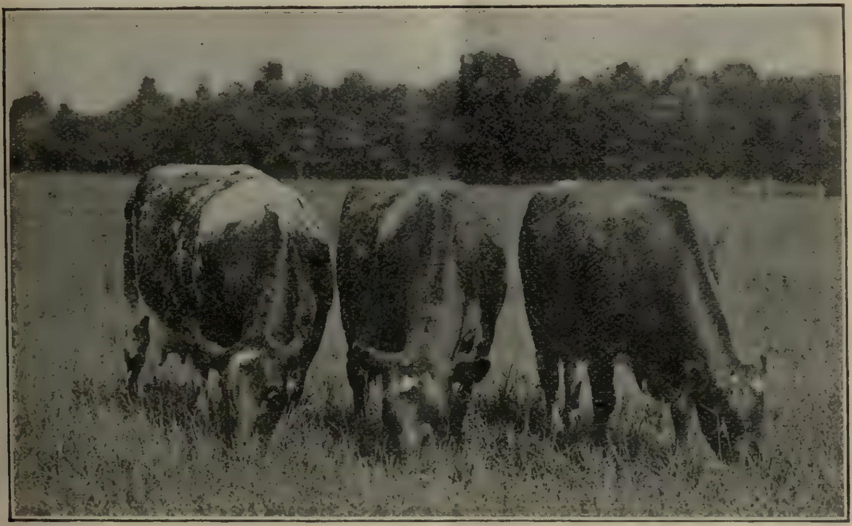

FIG. 4.—Thick-fleshed Shorthorn cows of good quality and conformity, suitable for the production of excellent baby beeves.

Farmers' Bulletin 612, "Breeds of Beef Cattle," discusses the characteristics of the different beef breeds. It may be obtained without charge by writing to the Department of Agriculture, Washington, D. C.

TYPE OF COWS TO USE.

In selecting cows from which baby beef is to be produced three very important factors should be kept in mind:

1. The cows should have at least a fair amount of beef blood. Pure breds are not necessary, but two or three crosses of such breeding is essential. Cows with a preponderance of dairy blood will not do for the production of baby beef. (See fig. 4.)

2. Cows best suited for this type of breeding usually weigh 900 pounds or over in thrifty breeding condition. So long as early maturity is not sacrificed, the heavier cows are the most suitable for baby-beef production. Size of frame rather than weight should govern in selecting cows which are to be used for this purpose.

3. The cows used to produce baby beeves should produce enough milk to keep the calves fat and growing without much additional feed up to weaning time.

In addition to these three factors, such things as constitution, uniformity of breeding, color, size, and early maturity should be considered. (See fig. 5.)

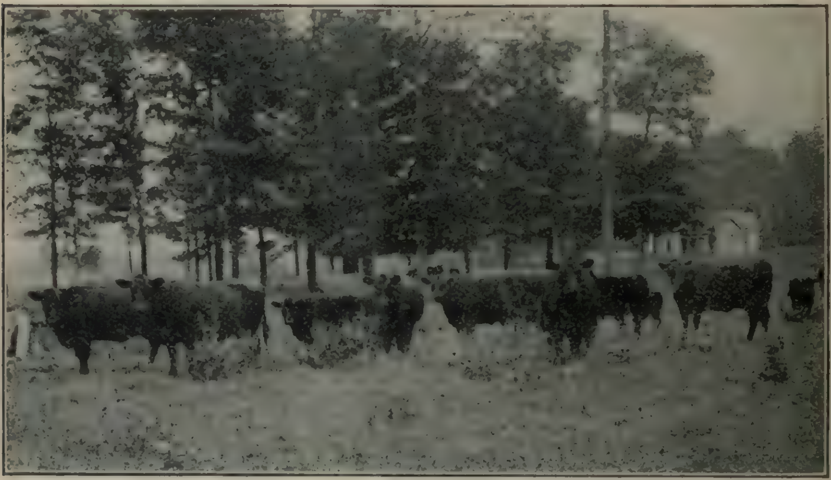

FIG. 5.—Aberdeen-Angus breeding cows that show uniformity of type and condition essential in producing calves suitable for baby-beef purposes.

TYPE OF BULLS TO BE USED.

As a general rule it may be said that lack of excellence in any one or all of the above-mentioned points in the cow may be offset through additional excellence in the herd bull. Some bulls seem to have sufficient prepotency to stamp their own excellence of form, type, and quality upon their calves regardless of the kind of cows in the herd. Such a bull is a very valuable asset to any breeder, and it is unfortunate that we can not tell absolutely what a bull will do in this respect until his offspring are seen. A bull coming from a line of ancestry which has been noted for its excellence of type, quality, milk-producing ability, and early maturity is more than likely to be a producer of animals like himself. This, together with individual excellence in the bull, is the only standard we have for forecasting the type of calves which an untried bull will get. For the producer of baby beef the additional sum paid for a good bull is money well spent.

Above all, a breeder in selecting a bull should procure one of good beef form and with a strong tendency toward earliness of maturity. (See fig. 6.) To a very large extent the breeder's success in raising and feeding baby beeves will depend upon the bull's ability to transmit this latter character to his calves. Quality and excellence of form in calves can not be obtained from poor breeding.

TYPE OF CALVES SUITABLE FOR BABY BEEF.

Calves to qualify as baby beef must have quality and finish. The consumer does not want the unfinished yearling, and the calf that does not have quality will not take on a high finish. Neither will the calf lacking in early-maturing qualities fatten during the latter part of the feeding period, but instead it will use most of the feed which it consumes for growth. Keeping this in mind, the feeder should first determine whether his calves are good enough to compete on the fat-yearling market, and if he decides that they are not, they should be finished off on coarser feeds for a later market.

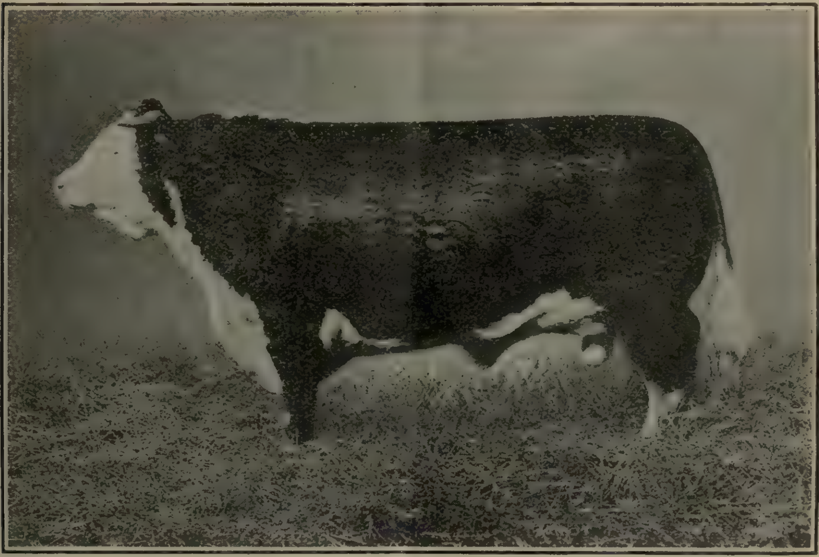

FIG. 6.—Bulls of high quality, showing thickness of flesh and early maturity tendencies, are desirable for siring.

The wide, deep-bodied, thick-fleshed calf with short legs and an abundance of quality as indicated by fineness of hair, texture of skin, smoothness of flesh, and general refinement about the head and other parts of the body is the type best suited for making prime baby beef. Uniformity in size, weight, and color should not be overlooked, because such factors are an advantage in marketing. These points are of great importance in selecting calves to be finished as baby beef, and they deserve the strictest attention. (See fig. 7.)

MANAGEMENT AND FEEDING OF THE BREEDING HERD.

SIZE OF THE BREEDING HERD.

Unless the breeder has some satisfactory method of marketing small lots of cattle, he should keep enough cows to produce at least one carload of baby beeves. A 36-foot car will hold approximately 27 head of calves averaging 950 pounds, or 25 head of 1,050-pound, calves. The average farmer can get an 85 per cent calf crop, and on this basis approximately 32 cows would be necessary to produce a carload of baby beeves a year.

Freight rates generally apply to a minimum weight per car, that is, the amount charged for freight is the same, even though the cars contain less than the minimum weight. Cattle ride better if the car contains the proper number. Either too few or too many in a car are bad, and the feeder will find it to his great advantage to have the car properly loaded.

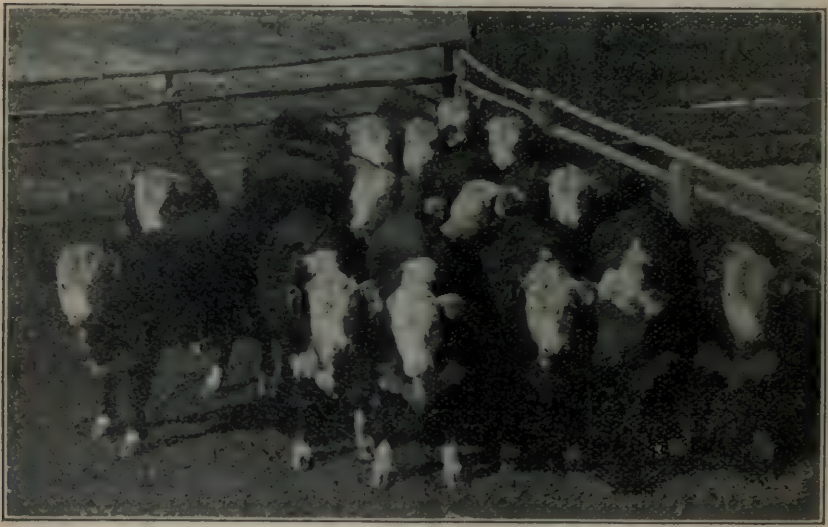

FIG. 7.—A group of well-finished baby beeves showing the uniformity of type, size, and quality which command the top prices for this class of beef.

In certain States have county or community live-stock shipping associations. Such organizations offer splendid opportunities for the shipper with less than a carload.[1]

The following table shows the approximate number of cattle and calves which can be shipped in cars of different lengths:

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[1] See Farmers' Bulletin 718, "Cooperative Live Stock Shipping Associations," and Department of Agriculture Bulletin 403, "Systems of Accounts for Live Stock Shipping Associations."

TABLE 1.—*Approximate number of cattle and calves that can be shipped in railroad cars of various lengths.*

Approximate weight of animals.	36-foot car.	38-foot car.	40-foot car.
400 pounds	45	48	52
600 pounds	38	40	42
800 pounds	30	32	34
950 pounds	27	28	30
1,050 pounds	25	26	27
1,150 pounds	22	23	24
1,200 pounds	20	22	23

Those feeders who have enough calves for two carloads have an advantage in that the animals can be graded, the better ones being placed in one car and the poorer ones in another; or, if the calves do not finish out uniformly, one carload can be shipped first, the other going later when finished.

The breeder who keeps a breeding herd of less than 30 cows will find that his bull charge per calf will be somewhat greater than when the bull is used on a larger herd. A well-matured bull can easily take care of 50 cows and ofttimes as many as 60. The breeder who does not keep enough cows to place the keeping of a bull on an economical basis will find an advantage in cooperating with a neighbor in the ownership of a bull.

FIG. 8.—A prime load of baby beeves. Grand champion carload at the International Live-Stock Exposition in 1916.

The amount of pasture available is a governing factor in the size of the breeding herd. Great care should be taken that pastures are not overstocked. Good bluegrass or clover pastures will carry from 50 to 100 cows per 100 acres. Other pastures, with the exception of wheat, oats, or other small grains, will vary in carrying capacity from 50 down to 5 head per 100 acres. Pastures that do not furnish sufficient grass for one head to each 6 or 8 acres are hardly good enough for breeding cows intended for growing baby-beef calves.

The amount of roughage, such as silage, hay, stover, straw, etc., is another very important factor in determining the size of the breeding herd. The basal portion of the ration for the breeding herd should be made up of these rough feeds, and if such home-grown feeds are not available, it is seldom advisable for the farmer to attempt to keep a herd of cows. From the stockman's standpoint the purchase of roughage at present prices is prohibitive, and the farmer who would realize the greatest profits from his breeding and feeding will plan to raise the feeds necessary for their maintenance.

BULL MANAGEMENT AND FEEDING.

The farmer with only a small number of cows will generally find it more economical to allow the bull to run with the herd. However, if the breeder wishes to breed the bull to 50 or 60 cows, which is the maximum number a mature bull should serve, the bull should be kept separate from the herd at all times and only one service should be allowed at each period of heat. Bulls running with the herd in large pastures will not get as many calves as when with the herd in a smaller pasture. Keeping the bull separate from the herd increases the cost of keeping him, but the bull cost per calf is usually cheaper except under range conditions or with very small herds. A mature bull when running with the cows in a small pasture should serve from 40 to 50 cows per year. Immature bulls should not be allowed to serve as many as this.

In feeding a bull care should be taken that he is kept in a thrifty condition. He should neither be pampered nor allowed to become thin. The grain ration may be judged almost entirely by his condition. A good grain mixture for the bull is one composed of one-fourth corn and three-fourths oats by weight. From 6 to 10 pounds daily of such a mixture for a 1,000-pound bull should be sufficient to meet all needs during the winter months. During the summer while on pasture he will need very little grain except during the breeding season, when he may be given daily from 3 to 5 pounds of the mixture mentioned above. Bran, barley, kafir, milo, etc., may be used in the bull ration if such feeds can be obtained at less expense than those mentioned.

The roughage ration should consist of some succulent roughage such as beets or silage, leguminous hay, as alfalfa or clover, and oat straw if it is available. A good roughage ration suitable for feeding when the bull is getting the grain ration mentioned above is 20 pounds of silage, 5 pounds of clover or alfalfa hay, and all the oat straw he will eat. The above weights are based on 1,000 pounds live weight. Johnson-grass hay, prairie hay, or mixed hays may be used in place of the roughages mentioned if prices warrant their use, but if any of these hays are used the grain ration should be slightly increased.

The bull should get plenty of exercise at all times. If kept in a stall or a small paddock he will not get the maximum number of calves. A roomy grass paddock where he can roam about at will is one of the best ways of giving him exercise. Nothing is better for the health and docility of a bull than moderate work in a treadmill.

BREEDING AND FEEDING THE COWS.

Uniformity in size and weight are very important factors in producing baby beef; therefore it is desirable that all the cows should calve within as short a period of time as possible. The average period of gestation for the cow is 283 days, or about 9½ months. To calve in April the cows should be bred during the latter part of June and up to the latter part of July. If the calves are desired in October the cows should be bred during December or January. The bull should be kept separate from the cows until the breeding season arrives. Every effort should then be made to get all the cows in calf during six weeks or two months, or in less time if possible. A cow generally comes in heat three times during 63 days, and those that are not in calf after three services should be disposed of.

Heifers should not calve before they are 27 to 30 months of age, and most heifers will do better if they are older than this at calving time.

Heifers and cows should be on pasture during as much of the year as possible. If pastures become short they should be fed a small quantity of grain. From one-half to 1½ pounds of cottonseed cake per day, depending upon the condition of the cows, is generally enough. If the grass is very sparse, silage or hay should be added to the ration, preferably the former. During the fall and early winter they will get good grazing in cornfields and meadows, although sometimes it will be necessary to supplement their feed at this time with a small quantity of roughage. It should be kept in mind that the most economical results in producing beef calves will be obtained when the cows are maintained largely on a roughage ration. At the present time silage is the most economical of all available farm roughages. Expensive hays should be avoided. Such feeds as straw and stover should be provided in such quantities as the cows will consume. Suitable winter rations for 1,000-pound breeding cows per day are as follows:

1.

Cottonseed meal, 1½ pounds.
Silage, 40 pounds.

2.

Cottonseed meal, 1 pound.
Corn stover, 10 pounds.
Oat straw, 5 pounds.
Silage, 30 pounds.

3.

Cottonseed meal or linseed meal, 1 pound.
Shredded corn stover, 20 pounds.
Clover hay, 4 pounds.

4.

Corn, 3 pounds.
Corn stover, 20 pounds.
Alfalfa or clover hay, 4 pounds.

5.

Cottonseed meal, 2 pounds.
Johnson grass, prairie, or mixed hay, 20 pounds.
Corn stover, 10 pounds.

6.

Corn-and-cob meal, 4 pounds.
Cottonseed meal or linseed meal, ¾ pound.
Hay (not leguminous), 15 pounds or unlimited.

In each of these rations the roughages such as silage, corn stover, and all hay except leguminous hays (alfalfa, clover, etc.) should be fed in such quantities as the animals will eat. The quantity of grain and clover or alfalfa hay fed should be controlled, and they should be given as the needs of the cows indicate. These are sample rations, and substitutions may be made as prices or availability of the feeds necessitate. The different constituents of these rations also may be increased or decreased as needed.

The table which follows may be of assistance in the management and feeding of the cow herd.

TABLE 2.—*Calendar of herd management in production of spring and fall calves.*

To produce spring calves.			To produce fall calves.		
Month.	What to do.	Feed.	Month.	What to do.	Feed.
July	Breed	Pasture with calves and bull.	January	Breed	Silage, 40 pounds; cottonseed meal, 2 pounds; or silage, 30 pounds, with corn stover or straw unlimited.
August		Pasture with calves.	February		Do.
September		Do.	March		Do.
October	Wean calves	Pasture.	April		Do.
November		Do.	May	Wean calves	Pasture.
December		Stalk fields, straw, meadow aftermath.	June		Do.
January		Corn silage, 40 pounds; cottonseed meal, 1½ pounds; or corn silage, 35 pounds, with stover unlimited.	July		Do.
February		Do.	August		Do.
March		Corn silage, 40 pounds; cottonseed meal, 1½ pounds; or corn silage, 35 pounds, with stover unlimited.	September		Pasture; 1 pound cottonseed cake.
April	Calves born	Cottonseed meal, 2 pounds.	October	Calves born	Do.
May		Pasture with calves.	November		Do.
June		Do.	December		Stalk fields, meadow aftermath; cottonseed cake, 2 pounds.

FEEDING THE HEIFERS.

Ordinarily, heifers intended for breeding purposes may be kept with the steer calves and fed in the same manner until the steers go on full feed. After this time the heifers should be fed separate from the breeding herd, and on a grain ration somewhat greater per 1,000 pounds live weight than that received by the cows. A good ration for heifers at this time is 2½ to 3 pounds of cottonseed meal or linseed meal with all the silage they will eat. When nearing maturity they may be fed with the cow herd. After about 9 months of age heifers will begin to come in heat, and until breeding time they should be kept separate from all bulls.

FALL OR SPRING CALVES.

Most of the calves on farms of this country are born during the spring months, but in recent years quite a number of farmers have adopted the fall calving plan.

The following seem to be the advantages of this system:

1. Calves born during the fall months are not bothered by flies, screw worms, maggots, etc., and hence they need less attention after castration and dehorning.

2. The young calf needs no grass until weaning time. The fall-born calf can therefore suckle its dam during the winter months and when weaned may go directly on pasture.

3. The fall-born calf fits in with pastures somewhat better than those born in the spring. His first summer is spent on the pasture, and at the end of this period he goes into the dry lot for finishing. On the other hand the spring-born calf must be fed during his first winter, and when the pastures are ready usually he can not be placed on them because he has reached the finishing period and should go into the dry lot.

4. The farmer who sells milk will derive greater profit when his cows freshen in the fall, since milk markets are better during the fall months.

5. Finishing calves in the fall and early winter interferes less with the other farm work than when it is done during the spring and early summer.

The disadvantages of fall calving are:

1. In extremely cold climates calves born in the late fall will suffer from the cold, and unless warm barns are available fall calving is not practicable.

2. More feed is necessary to maintain the cows when they are nursing calves, and during the winter months this will add somewhat to the expense of keeping the herd, since pastures are not always available.

3. Unless the farmer buys cows bred to calve in the fall he can not make the change from spring to fall calving without losing six months of service from the cows.

Those breeders who have tried the fall calving plan seem to favor it highly, but it will not work to advantage under all conditions.

BUYING OR RAISING CALVES.

In recent years the ranchmen of the West and South, more particularly the latter, have developed quite an industry in the breeding of high-quality calves which they furnish to feeders for finishing as baby beef. This system generally yields a fair profit to both breeder and feeder, but recent investigations indicate that the larger profits are gained where the calf is grown and fattened on the same farm.

With the development of drought-resistant grains, such as milo and kafir, ranchmen may find more profit in finishing the calves themselves rather than shipping them to corn-belt feed lots at weaning time.

With the feeder the buying of calves involves additional freight and commission charges as well as the paying of a profit to the breeder for growing the calves, all of which is saved when the feeder raises his own calves. However, if the feeder has not enough pasture or roughage to keep a breeding herd, or if the labor necessary to take care of a breeding herd is not available, it will, of course, be better for him to purchase his feeders.

SYSTEMS OF MANAGEMENT.

The distinction between different systems of management of the breeding herd and the calf herd chiefly pertains to the methods of handling and feeding the calves up to weaning time. The four systems practiced most extensively in the United States are those which have been arbitrarily named as follows:

1. The beef system, in which the cows are kept strictly for the calves they produce, and all calves are allowed to nurse their dams. Such calves usually run with their dams at all times.
2. Double nursing, or the system whereby some of the cows are required to suckle two calves rather than one, the cows without calves being milked.
3. Partially milked, or the system of allowing the calves to take a portion of the milk, the balance being hand milked.
4. Dual purpose, where the herds are kept for both beef and milk purposes. Under this system the cows are milked and the calves are raised on skim milk and grain.

The straight beef system is advisable in cases where the cows do not give enough milk to justify milking or where the cow herd is too large to permit of milking, where good feeds are scarce, when the cattle are kept under range conditions, where labor is very high or unobtainable, where the calves are allowed to take all the milk in order to get the greatest growth possible, or where the farm is not located near a good market for milk products. A great advantage in this system is that the calves can be allowed to run continuously with their mothers. When on pasture the cattle need very little attention, while with the other systems the handling of the herd involves additional attention and labor.

The double-nursing system appears to be the best where the cows are milked. An investigation recently completed by the Department of Agriculture[1] seems to indicate that this system is the most economical of all beef-producing systems used in the corn belt. The additional profits come through the sale of milk and milk products. The system, however, is advisable only where the breeding herd is composed of heavy milking cows.

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[1] Report No. 111, Office of Secretary, "Methods and Cost of Growing Beef Cattle in the Corn Belt States."

The partial-milking system is used more extensively in the Southeast than in any other section. It involves a great deal of trouble and labor and is not practicable on the average beef-producing farm.

The dual-purpose system does not generally yield very satisfactory results in raising calves to be finished out as baby beef, because it is very difficult to grow such calves on skim milk. Calves grown in this manner lose their baby fat, and few feeders can get the growth and finish out of such calves in time to sell them as baby beef.

The first two systems mentioned, the beef and the double-nursing, are the two which will be found most satisfactory for the production of prime baby beef.

CALF MANAGEMENT AND FEEDING.

DEHORNING, CASTRATION, AND VACCINATION.

Of the many problems confronting the producer of baby beef, those of greatest importance during the first six months of the calf's life, aside from that of feeding, are the castration, dehorning, and vaccination of the calf. Some breeders very successfully perform all of these operations at one time. When dealing with spring-born calves, these are generally operated upon during the late fall months when around 6 months of age (see Tables 3 and 4). This method is recommended, as it saves labor in the actual operation as well as in the care of the calf afterwards.

Calves can be dehorned successfully through the use of caustic potash on the horns when the calf is under 10 days of age. However, good results will usually be obtained and less labor is involved if the horns are sawed off when the calf is around 6 months of age, as mentioned above. When sawing off the horns the operator should be careful that about one-quarter of an inch of hair and skin is removed with the horn. During fly time pine tar may be used over the wound to prevent screw-worm or maggot infestation.

Losses through castration generally occur through improper wound drainage and can be prevented if the castration wound is made large enough. In making the cut through which the testicles are to be removed, the scrotum is grasped in the left hand and a slit is made from one end of the scrotum to the other over each testicle with a sharp knife which is held in the right hand. The testicles are then forced one at a time through the openings. The cords may be severed either by scraping with a knife or through the use of a castrating instrument made for this purpose.

In localities where blackleg is prevalent all calves should be vaccinated so as to prevent this disease. The first vaccination, as stated above, may be made at the time of dehorning and castration. In some communities it is advisable to vaccinate once each six months, as the vaccine gives only temporary immunity. The vaccination is generally done during both the spring and fall months.

FEEDING THE CALF FROM BIRTH TO WEANING TIME.

Unless the cows in the herd are exceptional milkers, calves intended for baby beef should be fed a conservative ration of grain, beginning as soon as the calves will eat grain. Nothing so stimulates growth and early maturity as milk sucked fresh from the dam, but in all cases baby-beef calves should be fed liberally on grain for at least one month before weaning time. They can be started on grain when 4 to 6 weeks of age, with the crushed grains of corn, kafir, milo, barley, wheat, or oats, etc. The first mentioned is well suited to their needs. After a few weeks the grain may be given whole.

WEANING.

As weaning time is the crucial period with baby-beef calves, every effort should be made to get them through this period without the loss of their calf fat. The grain ration should be increased to the extent that the loss of their milk after weaning will cause very little change in their growth and fattening. Some feeders provide "creeps" for their calves at this time. These creeps are built in the pastures or in the lots so that the calves can get their grain without disturbance from the cows. They consist of small pens fitted with openings of such size as to permit only the calves to enter. These openings should have rollers on each side so as to prevent bruising or other injury to the calves when entering the pen.

Calves should be weaned gradually. If they are running with the cows at all times, the weaning may be started by keeping them up and allowing them to suck only twice each day for five or six days, after which they should be allowed to suck only once a day for a similar period. Then one day's sucking may be omitted, and later on two days may be skipped. The entire weaning should take from 10 to 15 days.

Fall-born calves should not be weaned until after the cows and calves are on grass. Spring-born calves should be weaned early enough in the fall to allow them some time on grass if possible. It is advisable to provide them with winter pastures such as wheat, oats, rye, barley, etc.

FEEDING THE CALF FROM WEANING TIME TO MARKET.

The feeding and management of the calf after weaning time depends greatly upon the time of the year when it was born and the age at which it is to be sold. Calves that are born in the spring are fed and managed differently from those born in the fall. The calf intended for market at 15 months of age must be fed and handled somewhat differently from those intended for sale at 18 months of age. To aid the feeder in handling calves under these different conditions the two tables which follow are given. Table 3 deals with spring-born calves and Table 4 with those born in the fall. The data in both of these tables will vary with the time of birth and the length of the feeding period.

TABLE 3.—*Calendar of management and feeding for spring-born calves to be finished in 15 and 18 months, respectively.*

Month.		Calves to be finished in 15 months.		Calves to be finished in 18 months.	
1	March	Born	With cows. On grass or milk.	Born	Same as 15-month calf.
2	April		do		Do.
3	May		do		Do.
4	June		With cows. On grass or milk; begin feeding shelled corn or corn meal, ½ to 1 pound.		Do.
5	July		With cows. On skim milk or grass; corn meal, 2 pounds.		Do.
6	August	Wean	On grass with cows or on skim milk; chopped corn, 2½ pounds.	Wean	Do.
7	September	Vaccinate, castrate, and dehorn.	Pasture; chopped corn, 4 pounds; silage and hay if necessary.	Vaccinate, castrate, and dehorn.	Do.
8	October	do	Pasture; chopped corn, 5 pounds; silage, 10 pounds.	do	Do.
9	November	Dry lot	Corn, 6 pounds; cottonseed meal, ½ pound; silage, 8 pounds; oat straw, unlimited; clover, 3 pounds.		Stalk fields, meadows; corn, 4 pounds; cottonseed meal, ½ pound; silage, 5 pounds; straw.
10	December	do	Corn, 7 pounds; cottonseed meal, 1½ pounds; silage, 10 pounds; clover, 3 pounds; oat straw, unlimited.		Corn, 5 pounds; cottonseed meal, 1 pound; silage, 10 pounds; oat straw, unlimited.
11	January	do	Corn, 8 pounds; cottonseed meal, 1½ pounds; silage, 12 pounds; clover, 3 pounds; oat straw, unlimited.		Corn, 6 pounds; cottonseed meal, 1 pound; silage, 10 pounds; oat straw, unlimited.
12	February	do	Corn, 9 pounds; cottonseed meal, 2 pounds; silage, 10 pounds; clover, 3 pounds; oat straw, unlimited.		Corn, 7 pounds; cottonseed meal, 1 pound; silage, 10 pounds; oat straw, unlimited.
13	March	do	Corn, 10 pounds; cottonseed meal, 2 pounds; silage, 9 pounds; clover, 3 pounds; oat straw, unlimited.	Heavy feed; or pasture, with grain.	Corn, 8 pounds; cottonseed meal, 1 pound; silage, 12 pounds; oat straw, unlimited.
14	April	do	Corn, 11 pounds; cottonseed meal, 2 pounds; silage, 8 pounds; clover, 3 pounds; oat straw, unlimited.	In dry lot	Corn, 9 pounds; cottonseed meal, 1 pound; silage, 14 pounds, or pasture; oat straw.
15	May	Sell	Corn, 12 pounds; cottonseed meal, 2½ pounds; silage, 8 pounds; clover hay, 3 pounds; oat straw, unlimited.		Corn, 10 pounds; cottonseed meal, 1½ pounds; silage, 14 pounds, or pasture; oat straw, unlimited.
16	June				Corn, 11 pounds; cottonseed meal, 2 pounds; silage, 16 pounds, or pasture; oat straw, unlimited.
17	July				Corn, 12 pounds; cottonseed meal, 2 pounds; silage, 15 pounds, or pasture; oat straw, unlimited.
18	August			Sell	Corn, 14 pounds; cottonseed meal, 2½ pounds; silage, 12 pounds, or pasture; oat straw, unlimited.

TABLE 4.—*Calendar of management and feeding for fall-born calves to be finished in 15 to 18 months, respectively.*

Month.		Calves to be finished in 15 months.		Calves to be finished in 18 months.	
1	October	Born	With cow	Born	Same as 15-month calf.
2	November		do		Do.
3	December		With cow, small amount hay and grain.		Do.
4	January		With cow; corn meal, 1 pound; hay, unlimited.		Same as 15-month calf; grain and hay, 1 pound.
5	February		With cow; grain, 2 pounds; hay, unlimited; small amount silage.		Same as 15-month calf; grain and hay, 2 pounds.
6	March	Castrate, dehorn, vaccinate.	With cow; grain, 3 pounds; hay, unlimited; pasture.	Castrate, dehorn, vaccinate.	Do.
7	April		do		Do.
8	May	Wean	Pasture; grain, 4 pounds; hay or silage, if necessary.	Wean	Same as 15-month calf; grain, 2 pounds.
9	June		Pasture; grain, 5 pounds; hay and silage, if necessary.		Same as 15-month calf; grain, 3 pounds.
10	July		Pasture; grain, 6 pounds; small amount of hay and silage.		Do.
11	August	Dry lot or heavy feed; on pasture.	Corn, 8 pounds; cottonseed meal, 1½ pounds; silage, 12 pounds; clover, 4 pounds; oat straw, unlimited.		Pasture; grain, 3 pounds.
12	September		Corn, 9 pounds; cottonseed meal, 2 pounds; silage, 12 pounds; clover, 3 pounds; oat straw, unlimited.		Do.
13	October		Corn, 10 pounds; cottonseed meal, 2 pounds; silage, 10 pounds; clover, 3 pounds; oat straw, unlimited.	Dry lot	Pasture; grain, 5 pounds.
14	November		Corn, 11 pounds; cottonseed meal, 2 pounds; silage, 9 pounds; clover hay, 3 pounds; oat straw, unlimited.		Corn, 7 pounds; cottonseed meal, 1½ pounds; silage, 14 pounds; alfalfa or clover, 2 pounds; oat straw, unlimited.
15	December	Sell	Corn, 12 pounds; cottonseed meal, 2½ pounds; silage, 8 pounds; clover hay, 3 pounds; oat straw, unlimited.		Corn, 10 pounds; cottonseed meal, 2 pounds; silage, 15 pounds; alfalfa or clover, 3 pounds; oat straw, unlimited.
16	January				Corn, 10 pounds; cottonseed meal, 2½ pounds; silage, 20 pounds; alfalfa or clover, 3 pounds; oat straw, unlimited.
17	February				Corn, 12 pounds; cottonseed meal, 2½ pounds; silage, 18 pounds; oat straw, unlimited.
18	March			Sell	Corn, 14 pounds; cottonseed meal, 2 pounds; silage, 15 pounds; oat straw, unlimited.

The rations indicated in the foregoing tables consist of corn, cottonseed meal, corn silage, clover hay, and oat straw. Other feeds may be substituted in the place of these. Barley, milo, kafir, and similar grains may be used in the place of the corn, but slightly larger quantities should be fed. Linseed-oil meal may be used in place of cottonseed meal. When neither of these meals is available, the roughage should consist chiefly of a high-grade leguminous hay. Alfalfa or other leguminous hays may be used in place of clover hay. Other silages, or beets, may be used instead of corn silage.

Oat straw is a valuable addition to all baby-beef rations, not because of its nutritive value but because of its slightly laxative and alterative effect. When available, oat straw should be kept before the calves at all times.

Outside of the class of feeds mentioned above there are a few that are highly effective in the finishing of baby beef. It has been found at experiment stations that rations consisting of a grain, some kind of oil meal, a succulent feed such as silage or beets, and a leguminous hay, such as clover or alfalfa, are generally productive of the best results. Some feeders, however, are finishing a fair type of baby beef on simpler rations.

Average rations suitable for the last six months of the feeding period are as follows:

1.

Corn, 10 pounds.
Cottonseed meal, 2 pounds.
Clover hay, 3 pounds.
Corn silage, 10 pounds.

2.

Corn-and-cob meal, 15 pounds.
Linseed-oil meal, 2 pounds.
Clover hay, 3 pounds.
Corn silage, 7 pounds.

3.

Corn, 10 pounds.
Cottonseed meal, 1½ pounds.
Alfalfa hay, 6 pounds.
Oat straw, unlimited.

4.

Barley, 12 pounds.
Beets or roots, 10 pounds.
Alfalfa hay, 5 pounds.
Straw, unlimited.

5.

Kafir or milo chop, 12 pounds.
Cottonseed meal, 2 pounds.
Silage (corn, kafir, milo, or cane), 12 pounds.

6.

Corn, 8 pounds.
Oats, 3 pounds.
Clover hay, 3 pounds.
Corn silage, 10 pounds.

7.

Corn, 12 pounds.
Alfalfa hay, 7 pounds.

8.

Corn, 6 pounds.
Molasses, 2 pounds.
Cottonseed meal, 1½ pounds.
Mixed hay, unlimited.

These rations are average for the main feeding period. A small quantity of grain is fed at the start, and the quantity is increased throughout the entire feeding period. Corn may be increased at the rate of about 1 pound a month, or more if the calves will take it. Cottonseed or linseed-oil meal may be increased from one-fourth of a pound a day to 2 pounds during the first six or eight weeks. If silage is fed a light ration is given at first, which is increased as rapidly as the calves will take it until the last six weeks of the feeding period, when it is decreased so that the grain ration may be increased.

MANAGEMENT OF CALVES ON PASTURE.

With good pastures the roughage portion of the calves' ration may be eliminated. The grain portion of the ration in some cases may be slightly reduced, although as a rule the calves should be given all the grain they will eat while on pasture. It is seldom advisable to carry calves through the entire finishing period on grass. A better finish is obtained when they are dry fed during the latter portion of the period. It is never advisable to change calves from the dry lot to pastures when on full feed. It is safe, however, to change from pastures to the dry lot during this period.

When pastures are very good some trouble may be experienced in getting the calves to consume enough grain for the best results. In such cases it is generally better to keep them away from the grass during a portion of each day.

In sections where winter pastures can be grown the feeder should make a strong effort to provide such pasture during the cold season, as the green feeds greatly reduce the cost of both growing the calves and fattening them.

HOGS FOLLOWING BABY BEEVES.

Hogs should always be permitted to follow baby beeves to utilize any grain which may be wasted by them, also the undigested grain found in the droppings. Good, thrifty shoats weighing from 70 to 100 pounds are best suited for this purpose. Heavy hogs in good condition are not active enough, and young pigs are unsatisfactory because of the danger of getting crippled or otherwise injured by the cattle.

The number of shoats to use depends on the kind of grain being fed, the quantity, whether ground or fed whole, the price, etc. If grain is cheap and is fed lavishly, or if extra grain is fed to the hogs, one pig may be allowed for each calf. Ordinarily one pig may be permitted to follow two calves, and if necessary some grain other than what is obtained from the droppings is fed in order to finish the hogs in 90 to 100 days, so that another lot of shoats may be put in the lots to be finished by the time the calves are ready to market.

The quantity of pork produced is quite an important item in fattening baby beef, as the profit made on the hogs materially influences the returns from the entire feeding operation. From 1 to 2 pounds of pork may be obtained for each bushel of shelled corn fed to the calves.

If extra grain is fed to the hogs it should be given before the calves are fed and at some distance from the feed bunks. A separate feeding floor, watering facilities, and sleeping quarters should be provided for the hogs.

HOW LIVE STOCK IS HANDLED IN THE BLUEGRASS REGION OF KENTUCKY

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THE bluegrass region of Kentucky takes its name from the grass that long ago determined the trend of its agriculture, and that remains to this day the dominant factor in its farm business. Bluegrass grows luxuriantly on the richer soils of this region, and, if not held in check by cultivation, it holds its own against all enemies. For many years the farmers of central Kentucky have depended upon this grass for keeping up the fertility of the soil.

The characteristic system of farming developed here is essentially a grazing system, with tobacco, corn, wheat, clover, and a few minor crops supplementing the live-stock enterprises. The especially successful farmers among the 187 whose enterprises are discussed in this bulletin made beef cattle their leading stock enterprise, keeping sheep and hogs principally to utilize materials that otherwise would be wasted.

HOW LIVE STOCK IS HANDLED IN THE BLUEGRASS REGION OF KENTUCKY.

CONTENTS.

	Page.
Importance of knowing the best practice	1
What the bluegrass region farmer may do to increase his profits through live stock	1
Utilization of waste products by means of animals	6
Feeding practice and cost of feed for different kinds of animals common on bluegrass farms	7
Analyses of business on six individual farms	11

IMPORTANCE OF KNOWING THE BEST PRACTICE.

THE object of this bulletin is to show how live stock is handled and fits into the farm organization in the bluegrass region of Kentucky. The average successful farm of any long-established type will have various kinds of live stock distributed in about the proportion that owners or operators in general believe will pay best. Thus, a gradual process of selection is going on constantly in all agricultural regions, and it should be to the farmer's interest to know the best practice in his community and to have explained the economic advantages that have been secured by such practice.

In this bulletin an effort has been made to bring out the fundamental practices that make for success with live stock in central Kentucky as determined by the practices of the more successful live-stock farmers of that region.

WHAT THE BLUEGRASS REGION FARMER MAY DO TO INCREASE HIS PROFITS THROUGH LIVE STOCK.

To understand clearly the relation that live stock has to profitable farming in this section the farmer must have in mind the actual conditions which confront him.

Conditions in the bluegrass regions of the South Central States are unusual. Much of the land is hilly; some of it mountainous. The composition of the soil, its occasional shallowness, and the general lay of the land render it peculiarly subject to erosion. For this reason it is difficult to lay out fields in such a way as to allow a definite rotation of field crops, meadow, and pasture. Irregular areas must be kept in grass an indefinite time to prevent erosion or to build up the soil. In other words, the planning of the fields must be accommodated to the lay of the land, soil conditions, and the state of fertility of particular plats of ground. Each farm, then, has its peculiar problem in this respect, being unlike farms in much of the corn belt, where one farm is almost exactly like another in respect to these features and where fields may be laid out in any form suitable to the particular type of farming or crop rotation the farmer wishes to follow.

The conditions just mentioned explain in large part why live stock and tobacco are keys to successful farming in the blue-grass region. Blue grass keeps the soil from washing away and at the same time is a crop that can be utilized profitably by live stock. Land kept in blue grass a few years recuperates in productive power. It is thus a practical means of keeping up soil fertility. Tobacco, on the other hand, is an intensive crop. A large amount of time spent on a small area of productive land gives profitable returns. A normal crop of tobacco, requiring about 38 days of man labor per acre, will yield about 1,000 pounds of tobacco, which, at 13 cents per pound, would be worth $130, while an acre of corn requiring about 4.5 days' labor and yielding 40 bushels per acre would, at 60 cents per bushel, be worth $21. Thus a combination of grazing and tobacco farming with a few other crops used mainly for feed has proved to be the most generally profitable type of farming for this locality.

Since individual farms are so unlike, it is safe to make only the most general statements as to what farmers should do to increase their profits. In a survey of 187 blue-grass farms that was made in 1914 it was found that only about one-half of them were making the best use of their pastures. The importance of this fact will be realized when it is stated that on the average these farms had about 50 per cent of their area in pasture. Another outstanding factor in profitable farming is crop yield per acre. It was shown that crop yields increased with the increasing importance of live stock. For example, farms that had the equivalent of a 1,000 pound beef animal to each 5 to 7 acres of farm area almost uniformly had yields above the average. Farmers who had labor incomes[1] above $500 mostly had some sheep on the farm, enough at least to utilize products that otherwise would have been wasted. Those who had labor incomes below $500 and were counted unsuccessful, from a business standpoint, had practically no sheep. It is not contended that the number of sheep kept materially increased the farmer's income, but in this instance the sheep on the farm indicated good methods of management, and in this way the sheep became an indication of profitable farming.

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[1] Labor income—what is left the farmer after paying all expenses, including 5 per cent interest on his investment.

It would be impossible to tell definitely just how many beef cattle, young stock, dairy cows, sheep, and hogs a farm of a given size should have. The most successful farmers visited seldom had less than 1,000 pounds of live stock for each 6 acres of farm land; or, if all the live stock on the farm were numbered in terms of a beef animal, it would mean that one beef animal was kept for every 6 acres of land. Farms that had labor incomes below $500 and were rated as unsuccessful had an average of 1,000 pounds of live stock to about 10 acres of land.

The study made of these farms shows that when 50 to 60 per cent of the live stock was in beef animals the greatest profits were realized. The larger and cheaper farms of the region could handle even a greater percentage with profit. Among 130 farms very similar in type the group that had less than 30 per cent of live stock in beef animals made only $442 labor income; the group that had 55 to 62 per cent made $2,640; while those showing beef cattle above this percentage had only $1,340. Excepting small farms of 40 to 100 acres in size, on which it was necessary to intensify with tobacco, the farms making highest profits had 45 to 75 per cent of the farm area in bluegrass. Of course, the physical conditions on each individual farm will determine largely what the percentage should be, but the averages given point out clearly the best practice.

Only under exceptional conditions can farming be made to pay on the high-priced farms without tobacco. From 8 to 12 per cent of the crop area of the most successful of these farms was in tobacco. The smaller tobacco farms—40 to 100 acres in size—had a larger percentage, 15 to 20 per cent.

The analyses of several individual farms given in the latter part of this bulletin are meant to point out concretely the best practice to follow on farms of various sizes. Even these individual farms, however, can not furnish a model for all farms of the region, yet they offer valuable suggestions and illustrate the value of applying the fundamental principles of farm management.

The disposition of live stock on the successful farms of various types studied in 1914 was found to be as follows:

Live stock kept on certain successful farms in the bluegrass region studied in 1914.

Type of farm.[1]	Number of records.	Size of farms.	Actual number of animals.							Equivalent number of 1,000-pound steers.
			Beef cattle.	Swine.	Milch cows.	Young stock.	Mules and horses raised to sell.	Sheep.	Poultry.	
		Acres.								
Tobacco	15	170	7	21	5	4	4	26	128	*28*
Tobacco-stock	31	234	29	82	5	12	3	52	136	*68*
General mixed	13	315	12	44	6	14	3	52	138	*46*
Stock with tobacco	18	462	52	71	5	5	5	56	178	*89*
Stock with no tobacco	10	588	80	104	4	22	4	40	116	*116*

[1] The "tobacco" farm has 50 per cent or more of receipts from tobacco, with live stock least in importance. The "tobacco-stock" type of farm makes tobacco a major enterprise and gets 40 per cent or more of the receipts from this product. Live stock is second in importance. The "general mixed" farm makes all enterprises of about equal importance. The "stock with tobacco" type of farm makes live stock the major enterprise and tobacco secondary in importance.

UTILIZATION OF WASTE PRODUCTS BY MEANS OF ANIMALS.

On cheap land in a new and undeveloped section a profitable system of farming often develops which emphasizes a single enterprise, such as stock cattle or wheat. In these cases little thought is given to the utilization of by-products. Straw from the wheat field usually is burned. On grazing farms one class of live stock, such as sheep or stock cattle, pasture the entire area, little thought being given to the utilization of pasture by a combination of live-stock enterprises, or to the saving of manure. As soon as agricultural land becomes scarcer and higher in price, farming in most localities, however, must become more diversified. The organization must be such as to utilize by-products, to increase the value of field crops through utilizing the least salable products by feeding, to clean up the farm by proper grazing, and to increase the manure supply and make it more available. In the bluegrass region the best farmers understand these principles and an increasing number are putting them into practice. Many farmers there are now hogging down such crops as wheat, rye, and corn, in this way saving much of the expense of harvesting and marketing. It is commonly believed that by utilizing wheat in this way a better price can be obtained than by marketing the grain except when prices are abnormally high. The farmer may find also that the time saved by such a practice can be used profitably on other enterprises. Wheat and rye are hogged down from about the middle of June to the 1st of September, corn from September to December.

Sheep, horses, cattle, and swine all differ in their grazing habits. Sheep and horses will utilize the cured pasture under the snow where cattle would starve. Sheep eat young weeds and tender tree sprouts which other kinds of stock will not eat. Hogs may be harmful or useful as grazing animals, depending on many conditions with which the experienced farmer is familiar.

FEEDING PRACTICE AND COST OF FEED FOR DIFFERENT KINDS OF ANIMALS COMMON ON BLUEGRASS FARMS.

In the corn belt, where feeding beef cattle is common, feeders usually are bought during the summer and fall, grazed until the corn is husked, and turned into the cornstalk field to clean up after the huskers, and to utilize as much of the corn fodder as possible. Gradually they are put on full rations of grain and fattened in three to five months for the market. In the bluegrass region, in addition to stock cattle raised on the farm, the common practice is to buy stock cattle in the fall. These mostly are bought from the surrounding mountain farms, some from local farmers who do not make a practice of feeding and grazing, and a few from the general city markets. They graze on grass during the fall months and in the winter when pasture is available, and to some extent on rye and wheat fields during a period of four to five months. In the winter corn stover, straw, hay, occasionally silage, and some corn are fed. This dry feed is sufficient to maintain the animals in good condition; they may even gain a little in weight. Often the corn unhusked is hauled from the shocks standing in the fields and scattered about on the least fertile places on pasture land or on other parts of the farm. Grazing may begin early in the spring, but not so intensively as to make short summer pasture. Frequently droughts occur in the summer. If the pasture is not grazed too much in the early spring, the bluegrass will get an early start, and even if dry will be nutritious. Marketing is done in the fall about the time buying is done. Occasionally a farmer is found who fattens his cattle on corn silage and concentrated feed during the winter. In all cases hogs follow the cattle to clean up the waste.

It was found that the more successful farmers keep some sheep to utilize feed products which are not eaten by other animals and to assist in keeping farms clear of weeds.

On these farms a local market usually may be had for corn stover, sorghum, millet, pea hay, etc. Straw, if baled, may be sold on the market. However, to make these products more generally marketable would require more attention to curing and handling them, besides hauling them to market in many cases over bad roads. Hence, as a rule, the farmer could not get profitable market prices for much of the material now fed to productive live stock; so that, in the case of these products, live stock creates a market by being a profitable means of their disposal. The present prices on such feed products as corn, oats, and hay are governed very largely by prices demanded for similar products shipped in to supply the annual deficiency. Even corn and oats, raised quite extensively here, rarely become a surplus to be shipped out. For this reason the prices obtained and which the farmer usually can demand might not prevail if a much larger acreage of these products were grown. Such conditions must be taken into account in estimating the profitableness of the present amount of live stock carried on these farms.

The outstanding facts relative to the feeding practice and profitable utilization of feedable products on bluegrass farms are shown in the following averages, based on the estimates of 50 to 75 farmers:

Quantity and value of feed consumed by one steer or by an equivalent number of sheep or swine.

Kind of animals.	Feeding period of grain and concentrates.	Feeding period of hay and other forage.	Grain and concentrates fed.	Hay fed.	Straw and stover used.	Value of salable products consumed.	Estimated total value of feed.
			Pounds.	*Pounds.*	*Pounds.*		
Steer	Jan. 1–Apr. 7	Dec. 15–Apr. 25	840	200	1,600	$14.10	$28.90
7 sheep (equivalent to a steer)	Jan. 1–Mar. 20	June 1–Apr. 1	245	259	250	5.00	19.82
5 swine (equivalent to a steer)	July 20–Oct. 1[1]		3,000		250	37.88	45.29

[1] This is the finishing period on hogs. They get enough grain and pasture at other times to keep them in good growing condition.

Grain and concentrates fed to steers and sheep are reduced to corn equivalent and figured at 70 cents per bushel, or $1.25 per 100 pounds. Hay is figured at $12 per ton, the average farm price, or 60 cents per hundredweight. Other rough forage is figured at $3 per ton, the estimated average farm price for these products, or 15 cents per hundredweight. The average charge for pasture, all farms, was $1.87 per month per 1,000-pound animal, for six months. Winter pasture charge is assumed to be about 60 cents per month for six months. Hogs are charged with one-half as much pasture as other animals.

Cattle and sheep get relatively little grain during the period of dry feeding. Stock cattle are kept on the farm about a year, generally from October to October, making their gains on bluegrass pasture. The average gain, according to the estimates of 75 farmers on the difference between buying and selling weights of cattle, was 314 pounds. The average of these farmers' estimates of the gain that ought to be secured under favorable conditions was 340 pounds. The period of summer pasture will range from 160 to 200 days, or an average of possibly 180 days, but, as has been stated, the pastures furnish some grazing during the winter.

According to the figures given above, sheep consume the least amount of salable products during the winter season. They graze more during the year than any other class of animals, but a considerable amount of the products eaten are weeds which not only have no other value but are even positively injurious to farm crops. Assuming this to be the case, sheep are charged for pasturage at the same rate as stock cattle. Experience has taught the farmers that sheep, in order to be kept healthy and thrive well, must be changed from field to field frequently, so that the number than can be kept profitably on the farm is smaller than would otherwise be the case.

Swine consume more marketable grain than any other class of animals, but they also make larger gains from a given amount of feed. They also eat the undigested corn after cattle, and consume other unsalable products, such as spoiled corn or other spoiled grain, skim milk, etc. The experience of some farmers has shown that when hogs run most of the season on pastures having a mixture of grasses and clovers they will consume only about half the amount of grain they otherwise would. In bluegrass farming it is the general practice to allow hogs, as well as other kinds of live stock, to range over pretty much the entire farm during some part of the year. In the value of salable products consumed per 1,000-pound animal, grain concentrates, hay, straw, and corn stover have been included. The pasture charge is the average of the estimates of about 60 farmers in the localities studied.

In handling steers the farmer as a rule aims at least to sell at a cent a pound above cost price. Contracts to feed steers are occasionally made on this basis. On this basis the following statement would show the profits that might be expected from an 800-pound steer bought at 7 cents and sold at 8 cents when weighing 1,140 pounds:

Value of steer sold		$91.20
Value of manure (estimated)		6.50
Cost of steer	$56.00	
Value of feed (see p. —)	28.90	
Man labor	2.38	
Horse labor	1.47	
Interest on investment at 6 per cent	3.36	
Insurance and risk	.50	
	92.61	97.70

Buying and selling on this basis, the clear profit on such a steer would be $5.09, to which, however, would be added, in ordinary farm accounting, $7.21, representing wages for man and horse labor and interest on investment. Thus, the total return would be $12.30. In addition to this there is also a variable and often considerable profit on the hogs which follow the steers. The more successful farms, of course, would make a much better showing than this, which represents about the average of 178 farms.

In addition to this cash return one must consider the indirect benefits to the farm from live stock. As has been pointed out previously, live stock uniformly increases crop yields. It was found in the above-mentioned survey of Central Kentucky farms that the farmers who had the most live stock per hundred acres made the largest profits. Furthermore, live stock offers a reliable home market for much unsalable material and gives opportunity for utilization of much time that otherwise would be wasted.

It is the farmer who follows the best methods of animal husbandry and who is experienced in buying and selling who makes high profits. The fact that many blue-grass region farmers who gave records of their business failed not only to make any profits but had heavy losses shows that there is a great risk in the live-stock business and that only those who are experienced and who have capital or who have ample credit can safely carry on a large business of this kind.

It is a very difficult matter to compute, even approximately, actual profits on sheep or hogs alone. In the system of farming followed in this region, these two classes of animals are secondary in importance. As previously stated, they utilize much of what otherwise would be wasted. This being the case, a large increase in these animals on the farm would raise their feed cost very considerably. In this study it is assumed that the average successful farmer has through experience found approximately the proportion of various classes of animals that should be kept to secure, in the long run, greatest profits (see p. 5), so that actually, in measuring profits, the entire group of animals should be considered, rather than each class by itself. It is expected that each ewe on a farm will produce on the average one lamb a year, which at six months weighs 75 pounds, and will sell for $6 to $8, or an average of about $7 apiece. As hogs are handled ordinarily in this region, a sow may be counted on to produce on the average about 6 pigs a year, which could be sold, at an average weight of about 250 pounds, for $18 to $20 each. The risk on hogs, due especially to cholera, is larger than on any other class of animals. Risk is a large item in handling sheep also.

Considering all classes of live stock on 178 farms in the blue-grass region, it was found that on the average these made a net profit of $3.64 per 1,000 pound animal. The more successful farms, of course, made a much higher profit, while many, not so successful, showed a considerable loss on live stock. The fact, however, that the average of this group of farms paid the farmer the rent for his land, wages for his labor, and interest on his investment, in addition to this net profit, utilizing much material that otherwise would have been wasted, indicates that live stock is being handled at a profit in this region.

ANALYSES OF THE BUSINESS OF SIX INDIVIDUAL FARMS.

It is the purpose of the brief analyses of the individual farms that follow to present in a simple manner the outstanding features in the organization, and the main factors that influenced the profitableness of the business for the year 1913–14.

Total receipts include sales and increase of inventories for the year, less purchases of live stock. Expenses include all current expenses, depreciation, decrease of inventories, and an estimated value for unpaid labor such as work done by the family, except the operator's labor. Interest on capital is not included. The farm income is the difference between total receipts and expenses. The labor income is what is left after deducting 5 per cent interest on capital from the farm income. The farm produces a part of the family living and furnishes a house to live in. This is in addition to the farm income or the labor income. If the operator is also the owner of the farm and has no debts against it, he has the entire farm income to spend or invest. In case he is a tenant, his farm income includes only his labor income and interest on his working capital.

FARM NO. 1.

Size of farm ....acres	325	Live stock purchases	$1,000
Total capital	$30,000	Expenses	2,400
Working capital	8,200	Farm income	4,200
Investment in live stock	5,200	Labor income	2,700
Total receipts	6,600		
Total receipts from live stock	4,500		

This is a successful stock farm of medium size. The basic stock enterprises were 32 beef cattle, 99 hogs, and 70 sheep. All the animals on the farm, which included a few cows, young stock, horses and poultry, would, from the standpoint of feed consumed and manure produced, be equal to about 81 beef animals. One hundred and fifty-four acres of the farm area was in pasture, or about 47 per cent of the farm area.

All the crops on this farm, except 15 acres of hay, were raised by cropper labor. There were 50 acres of corn and 8 acres of tobacco. No regular help was hired, but $275 was spent for extra labor.

Crop yields were about 35 per cent above the average of the farms studied. The pasture area was well utilized—2 acres per 1,000 pounds of live stock.

This is a well-organized farm. The type and the general plan of management are well adapted to the cheaper, rolling lands.

FARM NO. 2.

Size of farm ....acres	203	Receipts from live stock	$3,720
Total capital	$31,000	Purchases of live stock	580
Working capital	5,400	Expenses	1,620
Investment in live stock	3,400	Farm income	3,600
Total receipts	5,220	Labor income	2,050

This is a smaller farm than the preceding one, but is organized in much the same way. The basic stock enterprises are about the same, 20 beef cattle, 100 sheep, and 39 hogs, equivalent to forty 1,000-pound animals out of a total of 52 on the farm. The crops on this farm were all raised by hired labor. Thirty acres of corn, 8 acres of meadow hay, 6 acres of oat hay, 3 acres of cowpeas, and 20 acres of tobacco were raised. The farm being smaller than the foregoing, good management is indicated by the comparatively large acreage of tobacco.

On this farm three laborers were hired for six months. A charge of $100 was incurred for extra labor, and the value of unpaid family labor was $86.

Diversity was less than on farm No. 1. As a rule in this section, it was found that the smaller farms had less diversity than the larger ones. This is due to the fact that in order to produce adequate income, the smaller farms must specialize more on some one or two enterprises.

About 50 per cent of the farm area was in pasture, the carrying capacity of which was about 2 acres per 1,000-pound animal, nearly twice the average.

For some reason, probably on account of severe local drouth, the average crop yields were nearly 20 per cent below the average of the farms studied. This was due to the particularly low yield of corn, which made only 20 bushels per acre. The hay yield, however, was above the average, being nearly 1½ tons per acre. The tobacco was about an average crop, but showed excellent quality in the fact that 14 cents per pound was obtained for it. This was about 12 per cent above the average for that year.

FARM NO. 3.

Size of farm..........acres..	966	Receipts from live stock......	$13,300
Total capital (operator)......	$71,000	Purchases of live stock......	5,500
Working capital..............	16,000	Expenses....................	8,600
Investment in live stock......	12,000	Farm income.................	8,900
Total receipts...............	17,500	Labor income................	5,350

Here we have an example of a large farm business. The operator owned 400 acres and rented 566 acres, for which he paid a cash rent of $2,800. This is the stock type of farm, the major enterprises being 101 beef cattle, 300 sheep, and 97 hogs, equal to about one hundred and fifty-seven 1,000-pound animals out of a total of nearly 172 on the farm. About 40 per cent of the farm area was devoted to pasture. There were 160 acres in corn, 175 in wheat, 80 in rye, oats, and barley, and 160 in meadow. Thirteen acres of tobacco were raised by a cropper. Two regular hands were hired. The amount paid for extra labor was $1,000.

Crop yields were a little above the average. The farm showed excellent utilization of pasture area, the carrying capacity being about the same as on the preceding farm—2 acres per 1,000-pound animal.

FARM NO. 4.

Size of farm acres	1,700	Receipts from live stock	$14,200
Total capital	$200,000	Purchases of live stock	13,400
Working capital	30,000	Expenses	9,600
Investment in live stock	18,000	Farm income	15,000
Total receipts	24,600	Labor income	5,000

This is a farm with still a larger business, mainly live stock. There were 247 beef cattle and 206 hogs, but no sheep. The number of all animals on the farm was about equal to 308 beef animals. There were 1,084 acres of pasture, or about 64 per cent of the farm area. The land was about the average in price ($100 per acre) and but slightly rolling. Two hundred and forty-five acres of corn and 26 acres of tobacco were raised by croppers. The operator with his hired labor raised 40 acres of corn for silage, 170 acres of wheat, 20 acres of oats for hay, and 18 acres of meadow hay. Two men were hired as regular hands, costing each $14 per month, with cottage and rations, and $675 was spent for extra labor. The croppers received one-half the crops they raised, which were valued at $4,200. The operator owned all of this land. Crop yields were 24 per cent above the average of the farms studied. The carrying capacity of pasture land was about 3 acres per 1,000-pound animal, or 33 per cent better than the average. This farm bought $1,000 worth of corn fodder and hay and $600 worth of concentrates. The buying of corn fodder was due partly, no doubt, to the fact that the corn was raised by croppers who got one-half of the products raised.

FARM NO. 5.

Size of farm acres	34	Receipts from live stock	$1,275
Total capital	$8,700	Purchases of live stock	925
Working capital	3,100	Expenses	475
Investment in live stock	1.900	Farm income	1,800
Total receipts	2,275	Labor income	1,300

Farm No. 5 shows that even on the small farm it is possible to be quite successful by specializing in stock. Usually, however, the small farm emphasizes the tobacco crop and in some cases dairying, in this way intensifying farming in order to make the business sufficiently large to produce an adequate income.

This farm, however, specialized in jacks. Three were sold for $1,450 and three bought for $750. The work stock were mares and the receipts from mule colts were $170. Only a few other animals were kept on the place. Seventeen acres, or 50 per cent of the land area, was in pasture. There were 8 acres of wheat, yielding 32 bushels per acre, and bringing in $256, while 3 acres of tobacco, yielding 1,500 pounds per acre, increased the income by $720. These are exceptional yields, showing the possibilities on the small farm with plenty of manure available.

There was practically no hired labor, but $100 of family labor was charged. Only $20 worth of feed was purchased.

FARM NO. 6.

Size of farm .... acres..	340	Receipts from live stock	800
Total capital (landlord)	$53,000	Purchases of live stock	1,400
Working capital (operator) .	2,400	Expenses	3,300
Investment in live stock	1,700	Farm income	−200
Total receipts	3,100	Labor income	−320

This farm failed to meet all the expenses of its operation. It was a rented farm, for which the operator paid $2,400 cash rent. The farm was valued at $150 per acre and was in one of the best farming sections of the bluegrass region. The quality of the soil was excellent. There were 8 beef cattle, 160 sheep, and 47 hogs, which would be equal to about 42 beef animals. These probably would utilize well the 120 acres of pasture—about 3 acres per 1,000-pound animal. Crop yields were 7 per cent above the average of the farms studied.

What was the matter with the management of this farm that it failed to be profitable?

In the first place, the amount invested in live stock was not sufficient. There should have been 150 or 160 acres in pasture, which with the quality of soil represented could have carried at least 75 1,000-pound animals or their equivalent. Probably too many sheep were kept in proportion to other kinds of live stock. Half the number, or between 80 and 100, would have made a better balance. Instead of 8 beef cattle, this farm could have well carried 35 to 40 such cattle and 80 to 100 hogs, the rest being cows, horses, young stock, and poultry. This would have required a much larger investment in working capital, and it is possible that this tenant was not able to borrow it. In that case it would have been better for him to have rented a smaller farm and specialized in tobacco, or possibly in dairying, depending on the opportunity to market his product and his ability to handle this business. The fact that he subrented 50 acres, for which he received $400, and share-rented 15 acres for tobacco, would further indicate that he was unable to handle a farm of this size.

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CONSTRUCTION AND USE OF FARM WEIRS

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FARMERS' BULLETIN 813

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

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CONTENTS.

	Page.
Need of farm weirs	3
Definitions	3
Advantages and disadvantages of weirs with complete contractions	4
Weir box and weir pond	5
Weir crests and sides	9
Weir gauge	10
Rectangular weirs	12
Cipolletti weirs	14
90° triangular-notch weirs	16
Units of measure	17

NEED OF FARM WEIRS.

In the arid west vast sums of money have been expended in the construction of ditch and canal systems to carry water to the lands where the rainfall is either insufficient or too uncertain for profitable agriculture, and the farmers have spent a still greater amount for preparing the land for irrigation and for purchasing "water rights," which entitle them to a certain amount of water. The value of the water has increased with the development of the country and now there is a general demand that the water be measured from the ditch to the irrigator as well as from the stream to the main canal. This is an important step toward better business methods in the management of canal systems and farms, and calls for accurate and reliable information concerning devices suited to the measurement of comparatively small streams of flowing water.

DEFINITIONS.

The "weir" is one of the most commonly used devices for this purpose. A bulkhead or wall built across a ditch or stream, with an opening cut in the top of the wall through which the water is allowed to pass, is called a "weir" and the opening is called the "weir notch." The bottom portion of the ditch immediately upstream from the bulkhead is the "weir box" or "weir pond." The height of the water surface in the weir pond above the weir crest is the "head." When the water flows over the crest into the air before it strikes the surface of the water in the ditch downstream from the bulkhead, it is said to have "free fall," and when this overpouring stream of water touches only the sharp upstream edge of the crest, the weir is

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NOTE.—The work on which this bulletin is based was done in the hydraulic laboratory at Fort Collins, Colo., under a cooperative agreement between the Office of Experiment Stations, United States Department of Agriculture, and the Colorado Agricultural Experiment Station.

For a technical report on the experimental data see Journal of Agricultural Research, Vol. V, No. 23, March 6, 1916.

The purpose of this bulletin is to give practical directions for the construction and use of the smaller sizes of weirs, such as are suited to the measurement of water on irrigated farms.

said to be "sharp crested." The weir notch must have a definite shape and size. The horizontal distance from the end of the weir crest to the side of the weir box is called "end contraction," and the vertical distance from the crest to the floor of the weir box is called "bottom contraction." When these contraction distances are great enough to cause a pondlike condition, which permits the water to approach the weir notch without any appreciable velocity, the weir is said to have "complete contractions."

The weirs described in this bulletin are the rectangular, Cipolletti, and 90° triangular-notch types, with free fall, sharp crests, and complete contractions. The discharge formulas for these weirs are not confined to the limits imposed upon old formulas. They are correct for high as well as low heads, at least within the range given in the tables.[1] However, in order to lessen the cost for materials for constructing the weirs, the dimensions of the weir boxes, as given in Table 1, are less than required for complete constructions, and therefore the discharges over these weirs will be greater than represented by the formula or discharge tables. The excess reaches a maximum of only about 1 per cent for the higher heads, and consequently can be ignored for practical conditions.

To determine the quantity of water flowing at any time, read the gauge, which gives the "head" or depth of water flowing over the weir notch, and turn to the discharge table in this bulletin for the type of weir used. If the head is measured in feet and decimals, find it in the first column, or if measured in feet and inches, find it in the second column, and following along this line to the right, find the number in the column for the length of weir crest used. This number will be the flow in cubic feet per second, which may be changed into miner's inches—or statute inches—by multiplying by the number of miner's inches equal to a cubic foot per second, as given in the table of hydraulic equivalents on the last page of this bulletin.

ADVANTAGES AND DISADVANTAGES OF WEIRS WITH COMPLETE CONTRACTIONS.

The principal advantages and disadvantages of the types of weirs described herein may be stated as follows:

> *Advantages.*—They are (1) accurate; (2) they are simple and may be constructed by the farmer; (3) they permit moss and floating trash to pass through the ditch without great danger of interfering with the measurement of the water; and (4) they are durable and require no adjustment for proper operation, for there are no working parts.

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[1] A full discussion of the experiments upon which these formulas are based is contained in Journal of Agricultural Research, vol. 5, No. 23, Mar. 6, 1916.

Disadvantages.—(1) They require a considerable pondage above the weir; (2) they can not be used where there is only a slight grade to the ditch; (3) they are not adapted to ditches that carry much sand and silt; and (4) practically all undesirable conditions, such as accumulation of sand and silt above the weir, water approaching the weir with velocity, or injury to the weir crest, tend to give a greater flow of water than that indicated in the tables.

WEIR BOX AND WEIR POND.

When properly constructed either of the three types of weirs described herein is reliable and accurate for the measurement of flowing water. They may be placed in any ditch or canal having sufficient fall, but it is necessary that the ditch be made wider and deeper for some distance upstream from the weir notch. This enlargement is for the purpose of making practically a still-water condition before water flows over the weir. The weir box or weir pond, which is immediately upstream from the weir notch, has a uniform length, width, and depth as given in Table 1, and commencing at approximately 50 feet upstream from the weir the ditch must be enlarged gradually from the regular size of the ditch to the full size of the weir box. The length of this tapering enlargement, stated as 50 feet, really needs to be greater or less as the flow in the ditch is large or small as compared to the size of the weir notch, and it will depend also upon the size of the ditch and the velocity of the water in the ditch.

Where the available grade in the ditch is not great enough to give the required depth of pond by raising the banks for a distance of 50 to 100 feet back from the weir, the bottom may be lowered and the banks raised only enough to give a free fall below the weir notch. However, the weir pond, whether a box or an enlargement of the ditch, must not be allowed to fill with silt and sediment or other débris. The water must approach the weir in straight lines without swirling or eddy currents.

A weir box may be built as shown in figure 1, or a bulkhead may be placed in an enlargement in the ditch as shown in figure 2. This latter arrangement will permit cleaning of the pond with teams and scrapers, and is easy and inexpensive to construct, but because of the sloping banks, the water surface must be wider than where a box is built with vertical sides. The bottom of the ditch for a short distance downstream from the weir should be lined with rock to prevent scouring due to the water falling over the weir notch. Where a complete weir box is built of timber or concrete it looks well, occupies the least land area and has greater permanency, but it is more costly and more difficult to clean. A floor or apron, as given in column K in Table 1, constructed of the same material as the weir box, over-comes the necessity for lining the ditch with rock below the weir. Precautions should be taken to prevent water from washing under the bottom or around the sides of the box. For most soils, if the earth is puddled with water as it is filled around the box, it will be safe; but where it is sandy or likely to wash, a board 12 inches wide should be placed on edge under the bottom and at the sides near the upper end of the box, to serve as a cut-off wall. The height of the weir crest above the bottom of the ditch downstream from the weir notch will depend upon the size and grade of the ditch, but this height must be such that when the greatest quantity of water is flowing over the weir the water level in the ditch downstream will be below the crest. This is to permit the free passage of air between the bulkhead and the sheet of over-pouring water, which is the required condition for free flow.

Table 1 gives the sizes of weirs best adapted to measuring flows of water varying from one-half to 22 cubic feet per second, and the proper dimensions for each size of rectangular, Cipolletti, and 90° triangular notch weirs.

TABLE 1.—*Weir-box dimensions for rectangular, Cipolletti, and 90° triangular-notch weirs.*

[All dimensions in feet. The letters at the heads of the columns in this table refer to figure 1.]

RECTANGULAR AND CIPOLLETTI WEIRS.

Flow (second-feet).	H. Maximum head.	L. Length of weir crest.	A. Length of box above weir. notch.	K. Length of box below weir. notch.	B. Total width of box.	E.[1] Total depth of box.	C. End of crest to side.	D. Crest to bottom.	F.[2] Hook-gage distance.	G.[3] Hook-gage distance.
½ to 3	1.0	1	6	[illegible]	5½	3½	2¼	2	4	2
2 to 5	1.1	1½	7	3	7	4	2¾	2½	4½	2
4 to 8	1.2	2	8	4	8½	4½	3¼	2¾	5	2½
6 to 14	1.3	3	9	5	12	5	4½	3¼	5½	[illegible]
10 to 22	1.5	4	10	[illegible]	14	5½	5	3½	6	3

90° TRIANGULAR NOTCH WEIR.

Flow (second-feet).	H.	L.	A.	K.	B.	E.	C.	D.	F.	G.
½ to 2½	1.00	....	6	2	5	3	2½	1½	4	2
2 to 4⅓	1.25	....	6½	8½	6½	3¼	3¼	1½	5	2½

[1] This distance allows for about ½ foot freeboard above highest water level in weir box.
[2] Equals distance from crest upstream to gauge.
[3] Equals distance from end of crest over to gauge.

As previously stated, using the weir boxes specified in Table 1 will give results within 1 per cent of correct. If smaller boxes are used the actual discharges will be larger than those given in the tables.

Tables 2 and 3 show the percentage increase in discharge caused by weir boxes smaller than required for complete contractions, for rectangular and Cipolletti weirs having crest lengths from 1 to 4 feet, and with heads of six-tenths and 1 foot.

If the smaller boxes are used, discharges should be read from the tables and increased by the percentages given in Tables 2 and 3.

TABLE 2.—*Velocity of approach and percentage of error caused by different end and bottom contractions for rectangular weirs.*

B. Distance of bottom below crest.	A. Distance of sides from end of crest.	Length 1 foot.				Length 1.5 feet.				Length 2 feet.				Length 3 feet.				Length 4 feet.			
		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.	
		Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.
Feet.	*Feet.*	*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*	
3.0	2.5	......	......	0.132	0.77	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
3.0	2.0	......	......	.157	.81	......	......	0.213	0.82	......	......	0.269	0.84	......	......	0.342	0.83	......	......	0.402	0.87
3.0	1.5	......	......	.196	.099	......	......	.260	1.08	......	......	.317	1.14	......	......	.399	1.22	......	......	.460	1.29
3.0	1.0	......	......	.260	1.40	......	......	.337	1.63	......	......	.398	1.81	......	......	.484	2.06	......	......	.543	2.22
3.0	.5	......	......	.40	2.94	......	......	.477	3.22	......	......	.540	3.44	......	......	.616	3.72	......	......	.661	3.88
2.5	2.5	......	......	.150	.74	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
2.5	2.0	......	......	.178	.82	......	......	.242	.88	......	......	.302	.94	......	......	.391	1.04	......	......	.460	1.11
2.5	1.5	......	......	.224	1.05	......	......	.297	1.21	......	......	.362	1.34	......	......	.461	1.57	......	......	.528	1.69
2.5	1.0	......	......	.299	1.58	......	......	.385	1.89	......	......	.457	2.14	......	......	.553	2.50	......	......	.623	2.76
2.5	.5	......	......	.462	3.42	......	......	.549	3.73	......	......	.625	3.99	......	......	.704	4.25	......	......	.760	4.48
2.0	2.5	0.94	0.17	.175	.73	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
2.0	2.0	.115	.26	.209	.84	......	......	.284	.97	......	......	.352	1.11	......	......	.458	1.30	......	......	.539	1.42
2.0	1.5	.148	.39	.261	1.13	......	......	.348	1.42	......	......	.424	1.67	......	......	.538	2.01	......	......	.620	2.28
2.0	1.0	.188	.66	.353	1.83	......	......	.450	2.28	......	......	.535	2.63	......	......	.648	3.14	......	......	.733	3.52
2.0	.5	.288	2.05	.538	4.01	......	......	.646	4.46	......	......	.728	4.80	......	......	.829	5.17	......	......	.895	5.47
1.5	2.5	.119	.17	.208	.74	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1.5	2.0	.141	.30	.252	.94	1.91	0.53	.341	1.18	0.239	0.74	.424	1.41	0.308	1.07	.539	1.71	0.365	1.33	.638	1.98
1.5	1.5	.175	.40	.314	1.31	.234	.73	.418	1.74	.286	1.01	.512	2.12	.363	1.44	.648	2.65	.416	1.74	.750	3.07
1.5	1.0	.234	.76	.424	2.24	.304	1.24	.544	2.87	.361	1.62	.646	3.40	.435	2.12	.790	4.14	.489	2.49	.889	4.68
1.5	.5	.355	2.26	.648	4.80	......	......	.784	5.53	......	......	.885	6.09	.552	3.41	1.013	6.77	......	......	1.091	7.20
1.0	2.5	.154	.19	.260	.82	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1.0	2.0	.209	.36	.314	1.12	......	......	.427	1.57	......	......	.532	2.00	......	......	.694	2.69	......	......	.810	3.15
1.0	1.5	.229	.50	.385	1.59	.311	1.09	.528	2.37	.377	1.55	.645	2.99	.478	2.25	.820	3.91	.552	2.79	.952	4.60
1.0	1.0	.303	1.01	.525	2.83	.400	1.77	.688	3.86	.476	2.39	.825	4.73	.577	3.22	.999	5.87	.650	3.83	1.135	6.77
1.0	.5	.469	2.84	.822	6.00	.573	3.74	.994	7.29	.646	4.38	1.129	8.29	.735	5.15	1.298	9.55	.794	5.64	1.405	10.27
.5	2.5	.221	.25	.350	1.11	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
.5	2.0	.265	.50	.417	1.45	.368	1.30	.575	2.40	.460	2.05	.720	3.27	.624	3.34	.943	4.62	.711	4.05	1.120	5.65
.5	1.5	.337	.94	.530	2.20	.453	1.94	.710	3.53	.555	2.84	.875	4.73	.705	4.17	1.119	6.50	.818	5.15	1.308	7.88
.5	1.0	.450	1.84	.716	3.83	.588	3.22	.930	5.65	.704	4.35	1.118	7.23	.862	5.92	1.380	9.40	.975	7.01	1.576	11.2
.5	.5	.695	4.63	1.120	8.25	.852	6.43	1.37	11.0	.970	7.79	1.58	13.3	1.112	9.40	1.83	16.01	1.208	10.50	2.01	18.0

TABLE 3.—*Velocity of approach and percentage of error caused by different end and bottom contractions for Cipolletti weirs.*

B.	A.	Length 1 foot.				Length 1.5 feet.				Length 2 feet.				Length 3 feet.				Length 4 feet.			
		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.	
Distance of bottom below crest.	Distance of sides from end of crest.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.
Feet.	*Feet.*	*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*	
2.0	2.0	....	....	0.250	1.19	....	....	0.322	1.22	....	....	0.386	1.24	....	....	0.488	1.28	....	....	0.561	1.30
2.0	1.5	....	....	.314	1.52	....	....	.397	1.70	....	....	.467	1.84	....	....	.575	2.08	....	....	.648	2.22
2.0	1.0	....	....	.422	2.40	....	....	.514	2.80	....	....	.590	3.15	....	....	.698	3.62	....	....	.769	3.92
2.0	.5	....	....	.655	6.16	....	....	.746	6.41	....	....	.813	6.61	....	....	.896	6.88	....	....	.951	7.01
1.5	2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1.5	2.0	0.158	0.84	.300	1.34	0.207	1.02	.388	1.49	0.251	1.21	.465	1.61	0.321	1.45	.590	1.82	0.373	1.61	.680	1.98
1.5	1.5	.196	1.11	.378	1.78	.255	1.38	.477	2.10	.304	1.60	.562	2.40	.377	1.95	.693	2.85	.429	2.19	.785	3.17
1.5	1.0	.260	1.70	.508	2.89	.329	2.08	.622	3.53	.381	2.36	.714	4.06	.454	2.77	.844	4.79	.504	3.02	.937	5.31
1.5	.5	.400	3.32	.795	7.29	.469	3.83	.906	7.79	.518	4.20	.989	8.18	.580	4.66	1.094	8.64	.617	4.93	1.163	8.85
1.0	2.5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1.0	2.0	.205	.09	.374	1.60	.274	1.25	.489	2.06	.331	1.55	.586	2.44	.425	2.05	.758	3.13	.492	2.39	.864	3.55
1.0	1.5	.257	1.20	.471	2.20	.335	1.71	.601	2.92	.400	1.55	.710	3.55	.500	2.82	.888	4.53	.569	3.30	1.003	5.19
1.0	1.0	.344	1.84	.643	3.76	.434	2.60	.787	4.83	.501	3.17	.908	5.73	.607	4.06	1.083	7.07	.671	4.60	1.200	7.92
1.0	.5	.529	4.00	1.010	9.20	.622	4.92	1.159	10.28	.690	5.61	1.271	11.08	.770	6.41	1.410	12.09	.826	6.98	1.503	12.72
.5	2.5	....	....	.64	3.3	....	....	.818	4.8	....	....	.968	6.07	....	....	1.21	8.07	....	....	1.391	9.56
.5	2.0	.300	1.11	.508	2.30	.399	1.81	.660	3.64	.487	2.42	.799	4.87	.625	3.40	1.013	6.73	.725	4.09	1.202	8.39
.5	1.5	.377	1.51	.640	3.30	.492	2.55	.818	4.80	.589	3.44	.969	6.09	.737	4.79	1.210	8.08	.847	5.80	1.391	9.56
.5	1.0	.505	2.39	.864	5.40	.636	3.93	1,077	7.58	.750	5.30	1.258	9.43	.908	7.18	1.505	11.95	1.013	8.39	1.688	1.38
.5	.5	.782	6.03	1.390	11.89	.932	8.02	1.605	14.63	1.037	9.43	1.782	16.85	1.173	11.28	2.015	19.80	1.263	12.48	....	....

WEIR CRESTS AND SIDES.

Weir crests and sides should be true, straight, and rigid. The crest must be level, the sides must be set to the proper angle with the crest, and carefully spaced to give the correct length of crest, as indicated by "L" in figure 1 and Table 1. The 90° triangular notch has no length of crest because the sides meet at a point.

It is not necessary that the sides and crest be sharpened to a knife edge, but the edge of the crest on the upstream side must be sharp in the sense that it is not rounded. If a depth of water not less than 3 inches is to be run over the weir, the crest thickness on the edge may be as great as one-fourth inch without the water adhering to the crest, provided the inner edge is sharp. However, if the crest is beveled, this bevel must be placed on the downstream side, for the upstream face of the crest and of the bulkhead which holds the crest must be even and in a vertical position. The downstream face of the opening in the bulkhead must be beveled outward and downward about 45 degrees to insure free passage of air under the sheet of water as it flows over the weir.

Instead of cutting the notch in the bulkhead to just the size desired and leaving this rather rough edge to serve as the crest and sides of the weir notch, it is better to make the opening in the bulkhead at least 1 inch deeper and 2 inches wider than the desired size of weir opening. This will permit attachment of crest and side strips to the bulkhead so as to project about an inch all around, making more perfect edges, and the overpouring sheet of water will not touch the bulkhead.

Wood may be used for the crest and sides, but as it is apt to warp, wear, and become splintered, metal is preferable. For the smaller sizes of weirs, the proper weir opening may be cut out of a single sheet of metal which may be fastened to the bulkhead. For the larger weirs crests and sides made from separate strips of metal having the edges filed true are more practical. This metal should be fairly heavy, to prevent the strips from bending and getting out of alignment easily. A more durable crest may be made of 1½-inch angle iron cut to the required lengths and set into the bottom and sides of the opening cut in the bulkhead. One face of the angle iron will be flush with the upstream side of the bulkhead and the other face will be fastened securely into the opening in the bulkhead. The edge over which the water will pass therefore will project 1½ inches from the opening in the bulkhead, and should be made true with squared edge.

If strips of wood are used for the crest and sides, they usually are fastened to the upstream face of the bulkhead for convenience, but in this case these strips must not be narrow, as this would give a projection the thickness of the strip, which will reduce the accuracy of the measurement of the water. With whatever type used, the joints formed by the sides and crest must fit nicely without leaving a crack and without causing an offset.

WEIR GAUGE.

The weir gauge, which is used to measure the depth of water flowing over the weir crest, may be an ordinary "ruler" or a hardwood stick graduated to feet and inches, but it is preferable to have it graduated to feet, tenths and hundredths of a foot. It should be set upstream from the weir notch a distance ("F" in fig. 1 and Table 1) at least four times the maximum depth of water ("H") to be run over the crest, or, if placed on the weir bulkhead, the distance "C," measured out from the end of the weir crest, should be at least two times the depth "H." If a complete weir box has been built, the gauge may be fastened to the bulkhead or the side of the box, as indicated in figure 1. If, instead of a weir box, an enlargement has been made in the ditch above the bulkhead, the gauge may be attached to a solid post set just far enough from the bank to insure that it always will be in the water. If a perma-

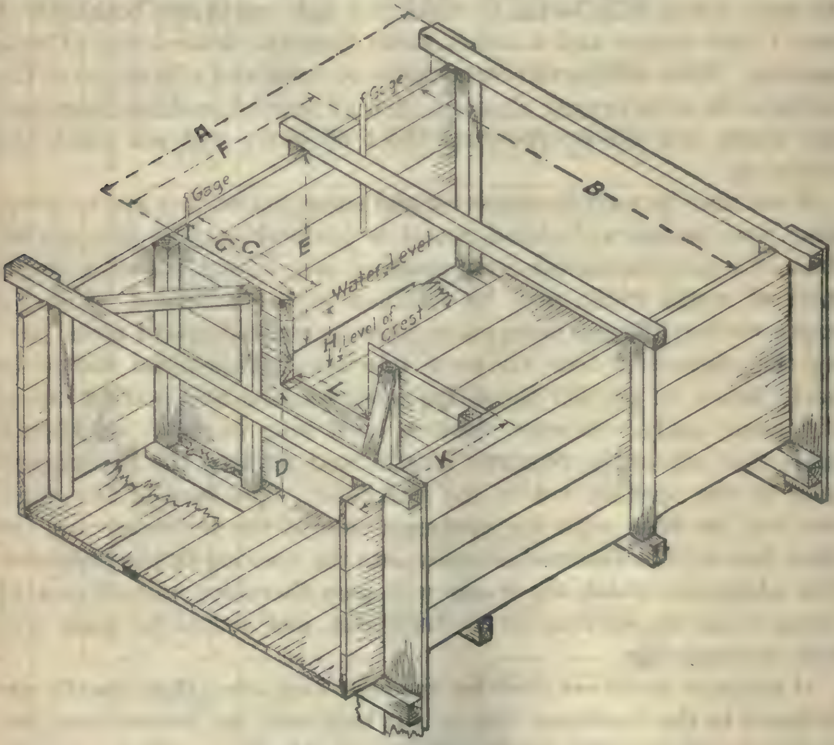

Fig. 1.—Plan of weir box.

nent gauge is not desired, a block or other solid support should be provided at the proper distance upon which to set a scale when taking readings.

The reason for placing the gauge as described is that the depth of water "H," from which the flow over weirs is computed, is measured vertically from the weir crest to the horizontal plane of the still-water surface in the weir pond upstream from the weir. There is a decided curving downward of the water surface near the weir notch, and it is necessary to get beyond the effect of this curvature, called "draw down," in order to get the correct depth of water "H."

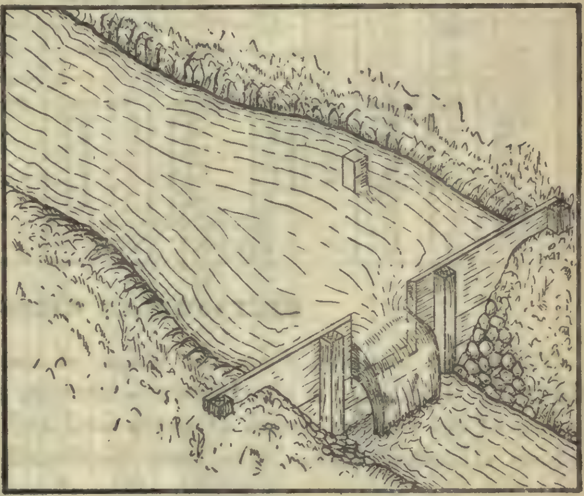

Fig. 2.—Weir notch and bulkhead in weir pond.

The zero of the gauge should be set level with the weir crest for rectangular and Cipolletti weirs, and with the lowest point in the 90° triangular notch, which has no real crest; but this level should not be determined by allowing the water to start to flow over the weir crest and marking the zero of the gauge from that water level, for, in fact, the water level must be appreciably higher than the crest before it will pour over the weir. It would be better to set the gauge with a good carpenter's level. Furthermore, before the beginning of each irrigation system, or oftener, the position of the weir crest and sides and the gauge should be checked carefully, for frost action or settlement in the wet soil may have altered their original position.

Where a hook gauge or an automatic recording gauge is to be used in connection with the weir, a water-tight still-box or gauge well should be provided outside of the weir box and connected to the weir box by means of a pipe laid through the bank below the level of the weir crest. The still-box should be placed upstream from the weir notch, a distance at least as great as shown in column "F" in Table 1, and should be enough deeper than the pipe to prevent silt accumulation from stopping the free passage of water through the pipe. It should be cleaned occasionally. The purpose of the box is to provide a still-water surface at the same level as the water in the weir box.

In order to obtain a correct measurement of the water flowing over a weir it is very necessary that the depth of water "H" be determined accurately. This means that the gauge must be placed accurately and read carefully. To show the error caused by misreading the gauge 0.01 foot, or slightly less than one-eighth inch, Table 4 is given.

TABLE 4.—*Percentage of error in discharge caused by 0.01 foot error in reading the head.*

Head.		Length of weir crest.					90° notch.
		1 foot.	1.5 feet.	2 feet.	3 feet.	4 feet.	
Feet.	*Feet. Inches.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0.20	0 2⅜	7.2	7.5	7.5	7.6	7.6	....
.30	0 3⅝	5.0	5.1	5.1	5.6	4.8	8.5
.50	0 6	3.5	3.2	3.0	2.9	2.9	5.0
.70	0 8⅜	2.1	1.9	2.1	2.2	2.2	3.9
.90	0 10 13/16	1.8	1.8	1.8	1.7	1.7	2.9
1.10	1 1 3/16	....	1.4	1.3	1.3	1.3	2.2
1.25	1 3	....	....	....	1.1	1.1	2.1
1.50	1 6	....	....	....	0.9	1.0	....

RECTANGULAR WEIRS.

The name is taken from the shape of the weir notch, shown in figure 3. This weir is also known sometimes as the Francis weir. It is one of the earliest forms of weirs used and really is the type from which all other forms have been developed. Because of the simplicity, ease of construction and accuracy with which the crest and sides may be set with the implements ordinarily at hand, this type of weir demands a wider use than it has received in the past few years. It is equally as accurate as the other types. The crest is placed in a horizontal position and the sides extend vertically above the crest. The angle formed therefore is a right angle, which permits the weir to be set easily and accurately by means of a carpenter's square and level. The sides must be placed carefully to give the desired length along the crest. Table 5 gives the discharge over rectangular weirs from 1 to 4 feet in length, computed from the corrected formula.

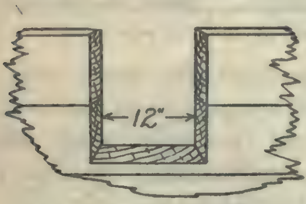

FIG. 3.—Rectangular weir.

TABLE 5.—*Discharge tables for rectangular weirs.*

Computed from the formula $Q=3.247\,lH^{1.48}-\frac{0.566\,l^{1.8}}{1+2\,l^{1.8}}\,H^{1.9}$.

Head in feet.	Head in inches.	Discharge in cubic feet per second for crests of various lengths.				
		1 foot.	1.5 feet.	2 feet.	3 feet.	4 feet.
0.20	$2\frac{3}{8}$	0.291	0.439	0.588	0.887	1.19
.21	$2\frac{1}{2}$	.312	.472	.632	.954	1.28
.22	$2\frac{5}{8}$	.335	.505	.677	1.02	1.37
.23	$2\frac{3}{4}$	.358	.539	.723	1.09	1.46
.24	$2\frac{7}{8}$	.380	.574	.769	1.16	1.55
.25	3	.404	.609	.817	1.23	1.65
.26	$3\frac{1}{8}$	.428	.646	.865	1.31	1.75
.27	$3\frac{1}{4}$	.452	.682	.914	1.38	1.85
.28	$3\frac{3}{8}$	.477	.720	.965	1.46	1.95
.29	$3\frac{1}{2}$	.502	.758	1.02	1.53	2.05
.30	$3\frac{5}{8}$	.527	.796	1.07	1.61	2.16
.31	$3\frac{3}{4}$	.553	.836	1.12	1.69	2.26
.32	$3\frac{13}{16}$	.580	.876	1.18	1.77	2.37
.33	$3\frac{15}{16}$	.606	.916	1.23	1.86	2.48
.34	$4\frac{1}{16}$	.634	.957	1.28	1.94	2.60
.35	$4\frac{3}{16}$	.661	.999	1.34	2.02	2.71
.36	$4\frac{5}{16}$	.688	1.04	1.40	2.11	2.82
.37	$4\frac{7}{16}$	.717	1.08	1.45	2.20	2.94
.38	$4\frac{9}{16}$	.745	1.13	1.51	2.28	3.06
.39	$4\frac{11}{16}$	.774	1.17	1.57	2.37	3.18
.40	$4\frac{13}{16}$	.804	1.21	1.63	2.46	3.30
.41	$4\frac{15}{16}$	.833	1.26	1.69	2.55	3.42
.42	$5\frac{1}{16}$	.863	1.30	1.75	2.65	3.54
.43	$5\frac{3}{16}$	.893	1.35	1.81	2.74	3.67
.44	$5\frac{1}{4}$	.924	1.40	1.88	2.83	3.80
.45	$5\frac{3}{8}$	.955	1.44	1.94	2.93	3.93
.46	$5\frac{1}{2}$	.986	1.49	2.00	3.03	4.05
.47	$5\frac{5}{8}$	1.02	1.54	2.07	3.12	4.18
.48	$5\frac{3}{4}$	1.05	1.59	2.13	3.22	4.32
.49	$5\frac{7}{8}$	1.08	1.64	2.20	3.32	4.45
.50	6	1.11	1.68	2.26	3.42	4.58
.51	$6\frac{1}{8}$	1.15	1.73	2.33	3.52	4.72
.52	$6\frac{1}{4}$	1.18	1.78	2.40	3.62	4.86
.53	$6\frac{3}{8}$	1.21	1.84	2.46	3.73	4.99
.54	$6\frac{1}{2}$	1.25	1.89	2.53	3.83	5.13
.55	$6\frac{5}{8}$	1.28	1.94	2.60	3.94	5.27
.56	$6\frac{3}{4}$	1.31	1.99	2.67	4.04	5.42
.57	$6\frac{13}{16}$	1.35	2.04	2.74	4.15	5.56
.58	$6\frac{15}{16}$	1.38	2.09	2.81	4.26	5.70
.59	$7\frac{1}{16}$	1.42	2.15	2.88	4.36	5.85
.60	$7\frac{3}{16}$	1.45	2.20	2.96	4.47	6.00
.61	$7\frac{5}{16}$	1.49	2,25	3.03	4.59	6.14
.62	$7\frac{7}{16}$	1.52	2.31	3.10	4.69	6.29
.63	$7\frac{9}{16}$	1.56	2.36	3.17	4.81	6.44
.64	$7\frac{11}{16}$	1.60	2.42	3.25	4.92	6.59
.65	$7\frac{13}{16}$	1.63	2.47	3.32	5.03	6.75
.66	$7\frac{15}{16}$	1.67	2.53	3.40	5.15	6.90
.67	$8\frac{1}{16}$	1.71	2.59	3.47	5.26	7.05
.68	$8\frac{3}{16}$	1.74	2.64	3.56	5.38	7.21
.69	$8\frac{1}{4}$	1.78	2.70	3.63	5.49	7.36
.70	$8\frac{3}{8}$	1.82	2.76	3.71	5.61	7.52
.71	$8\frac{1}{2}$	1.86	2.81	3.78	5.73	7.68
.72	$8\frac{5}{8}$	1.90	2.87	3.86	5.85	7.84
.73	$8\frac{3}{4}$	1.93	2.93	3.94	5.97	8.00
.74	$8\frac{7}{8}$	1.97	2.99	4.02	6.09	8.17
.75	9	2.01	3.05	4.10	6.21	8.33
.76	$9\frac{1}{8}$	2.05	3.11	4.18	6.33	8.49
.77	$9\frac{1}{4}$	2.09	3.17	4.26	6.45	8.66
.78	$9\frac{3}{8}$	2.13	3.23	4.34	6.58	8.82
.79	$9\frac{1}{2}$	2.17	3.29	4.42	6.70	8.99
.80	$9\frac{5}{8}$	2.21	3.35	4.51	6.83	9.16
.81	$9\frac{3}{4}$	2.25	3.41	4.59	6.95	9.33
.82	$9\frac{13}{16}$	2.29	3.47	4.67	7.08	9.50
.83	$9\frac{15}{16}$	2.33	3.54	4.75	7.21	9.67
.84	$10\frac{1}{16}$	2.37	3.60	4.84	7.33	9.84
.85	$10\frac{3}{16}$	2.41	3.66	4.92	7.46	10.01
.86	$10\frac{5}{16}$	2.46	3.72	5.01	7.59	10.19
.87	$10\frac{7}{16}$	2.50	3.79	5.10	7.72	10.36
.88	$10\frac{9}{16}$	2.54	3.85	5.18	7.85	10.54
.89	$10\frac{11}{16}$	2.58	3.92	5.27	7.99	10.71
.90	$10\frac{13}{16}$	2.62	3.98	5.35	8.12	10.89
.91	$10\frac{15}{16}$	2.67	4.05	5.44	8.25	11.07
.92	$11\frac{1}{16}$	2.71	4.11	5.53	8.38	11.25
.93	$11\frac{3}{16}$	2.75	4.18	5.62	8.52	11.43
.94	$11\frac{1}{4}$	2.79	4.24	5.71	8.65	11.61
.95	$11\frac{3}{8}$	2.84	4.31	5.80	8.79	11.79
.96	$11\frac{1}{2}$	2.88	4.37	5.89	8.93	11.98
.97	$11\frac{5}{8}$	2.93	4.44	5.98	9.06	12.16
.98	$11\frac{3}{4}$	2.97	4.51	6.07	9.20	12.34
.99	$11\frac{7}{8}$	3.01	4.57	6.15	9.34	12.53
1.00	12	3.06	4.64	6.25	9.48	12.72
1.01	$12\frac{1}{8}$	......	4.71	6.34	9.62	12.91
1.02	$12\frac{1}{4}$	......	4.78	6.43	9.76	13.10
1.03	$12\frac{3}{8}$	......	4.85	6.52	9.90	13.28
1.04	$12\frac{1}{2}$	......	4.92	6.62	10.04	13.47
1.05	$12\frac{5}{8}$	......	4.98	6.71	10.18	13.66
1.06	$12\frac{3}{4}$	......	5.05	6.80	10.32	13.85
1.07	$12\frac{13}{16}$	......	5.12	6.90	10.46	14.04
1.08	$12\frac{15}{16}$	......	5.20	6.99	10.61	14.24
1.09	$13\frac{1}{16}$	......	5.26	7.09	10.75	14.43
1.10	$13\frac{3}{16}$	......	5.34	7.19	10.90	14.64
1.11	$13\frac{5}{16}$	......	5.41	7.28	11.04	14.83
1.12	$13\frac{7}{16}$	......	5.48	7.38	11.19	15.03
1.13	$13\frac{9}{16}$	......	5.55	7.47	11.34	15.22
1.14	$13\frac{11}{16}$	......	5.62	7.57	11.48	15.42
1.15	$13\frac{13}{16}$	......	5.69	7.66	11.64	15.62
1.16	$13\frac{15}{16}$	......	5.77	7.76	11.79	15.82
1.17	$14\frac{1}{16}$	......	5.84	7.86	11.94	16.02
1.18	$14\frac{3}{16}$	......	5.91	7.96	12.09	16.23
1.19	$14\frac{1}{4}$	......	5.98	8.06	12.24	16.43
1.20	$14\frac{3}{8}$	......	6.06	8.16	12.39	16.63
1.21	$14\frac{1}{2}$	......	6.13	8.26	12.54	16.83
1.22	$14\frac{5}{8}$	......	6.20	8.35	12.69	17.03
1.23	$14\frac{3}{4}$	......	6.28	8.46	12.85	17.25
1.24	$14\frac{7}{8}$	......	6.35	8.56	12.99	17.45
1.25	15	......	6.43	8.66	13.14	17.65
1.26	$15\frac{1}{8}$	......	......	......	13.30	17.87
1.27	$15\frac{1}{4}$	......	......	......	13.45	18.07
1.28	$15\frac{3}{8}$	......	......	......	13.61	18.28
1.29	$15\frac{1}{2}$	......	......	......	13.77	18.50
1.30	$15\frac{5}{8}$	......	......	......	13.93	18.71
1.31	$15\frac{3}{4}$	......	......	......	14.09	18.92
1.32	$15\frac{13}{16}$	......	......	......	14.24	19.12
1.33	$15\frac{15}{16}$	......	......	......	14.40	19.34
1.34	$16\frac{1}{16}$	......	......	......	14.56	19.55
1.35	$16\frac{3}{16}$	......	......	......	14.72	19.77
1.36	$16\frac{5}{16}$	......	......	......	14.88	19.98
1.37	$16\frac{7}{16}$	......	......	......	15.04	20.20
1.38	$16\frac{9}{16}$	......	......	......	15.20	20.42
1.39	$16\frac{11}{16}$	......	......	......	15.36	20.64
1.40	$16\frac{13}{16}$	......	......	......	15.53	20.86
1.41	$16\frac{15}{16}$	......	......	......	15.69	21.08
1.42	$17\frac{1}{16}$	......	......	......	15.85	21.29
1.43	$17\frac{3}{16}$	......	......	......	16.02	21.52
1.44	$17\frac{1}{4}$	......	......	......	16.19	21.74
1.45	$17\frac{3}{8}$	......	......	......	16.34	21.96
1.46	$17\frac{1}{2}$	......	......	......	16.51	22.18
1.47	$17\frac{5}{8}$	......	......	......	16.68	22.41
1.48	$17\frac{3}{4}$	......	......	......	16.85	22.64
1.49	$17\frac{7}{8}$	......	......	......	17.01	22.85
1.50	18	......	......	......	17.17	23.08

CIPOLLETTI WEIRS.

This type of weir is trapezoidal in shape, but the name "Cipolletti" is that of the Italian engineer who proposed its use. As shown in figure 4, the crest of the weir must be level, and the sides placed on a slope of 1 to 4, meaning one unit horizontal to four units vertical. The notch therefore is larger than a rectangle with the same crest length.

It is seen readily that the Cipolletti type of weir, or in fact any weir having sloping sides, is neither so easy to construct nor so easy to check later for accuracy as is the rectangular weir. The great popularity of the Cipolletti weir is due somewhat to its having been proposed at a time when the use of weirs for measuring irrigation water was being considered, but principally because the angle which the sides make with the crest was supposed to make the flow over the weir proportional to the length of the crest. In other words, the flow for a certain head on a 2-foot weir was supposed to be twice the flow over a 1-foot weir for the same depth of water, which would require but a simple weir table for field use. Recent experiments, however, prove that the flow over Cipolletti weirs is not proportional to the length of the crest, which apparently refutes the principal argument in its favor. However, if the sides are placed properly with respect to the crest, and other conditions are observed fully the flow can be measured as accurately over a Cipolletti weir as over a rectangular weir, if the accompanying weir tables, or formula, are used. It is all right, therefore, to use a Cipolletti weir if constructed properly, but where a weir is to be constructed, the rectangular should be chosen in preference to the Cipolletti type. Table 6 gives the discharge over Cipolletti weirs from 1 to 4 feet in length, computed from the corrected formula.

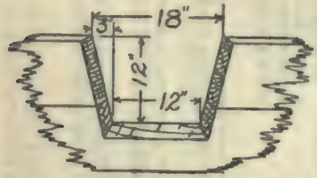

FIG. 4.—Cipolletti or trapezoidal weir.

TABLE 6.—*Discharge tables for Cipolletti weirs.*

Computed from the formula $Q=3.247\,lH^{1.48}-\frac{0.566\,l^{1.8}}{1+2\,l^{1.8}}H^{1.9}+0.609\,H^{2.5}$.

Head in feet.	Head in inches.	Discharge in cubic feet per second for crests of various lengths.				
		1 foot.	1.5 feet.	2 feet.	3 feet.	4 feet.
0.20	$2\frac{3}{8}$	0.30	0.45	0.60	0.90	1.20
.21	$2\frac{1}{2}$	.32	.48	.64	.97	1.29
.22	$2\frac{5}{8}$	.35	.52	.69	1.04	1.38
.23	$2\frac{3}{4}$	.37	.55	.74	1.11	1.47
.24	$2\frac{7}{8}$	.39	.59	.79	1.18	1.57
.25	3	.42	.63	.84	1.25	1.67
.26	$3\frac{1}{8}$	.45	.67	.89	1.33	1.77
.27	$3\frac{1}{4}$	.47	.70	.94	1.40	1.87
.28	$3\frac{3}{8}$	.50	.74	.99	1.48	1.97
.29	$3\frac{1}{2}$	.53	.79	1.04	1.56	2.08
.30	$3\frac{5}{8}$	.56	.83	1.10	1.64	2.19
.31	$3\frac{3}{4}$	.59	.87	1.15	1.73	2.30
.32	$3\frac{13}{16}$	.61	.91	1.21	1.80	2.41
.33	$3\frac{15}{16}$	.64	.95	1.27	1.89	2.52
.34	$4\frac{1}{16}$	.67	1.00	1.32	1.98	2.64
.35	$4\frac{3}{16}$	.70	1.04	1.38	2.07	2.75
.36	$4\frac{5}{16}$	.73	1.09	1.44	2.16	2.87
.37	$4\frac{7}{16}$	.77	1.13	1.50	2.25	2.99
.38	$4\frac{9}{16}$	.80	1.18	1.57	2.34	3.11
.39	$4\frac{11}{16}$	.83	1.23	1.63	2.43	3.24
.40	$4\frac{13}{16}$	.87	1.28	1.69	2.53	3.36
.41	$4\frac{15}{16}$	.90	1.32	1.76	2.62	3.49
.42	$5\frac{1}{16}$	.93	1.37	1.82	2.72	3.61
.43	$5\frac{3}{16}$	.97	1.42	1.89	2.81	3.74
.44	$5\frac{1}{4}$	1.00	1.47	1.95	2.91	3.87
.45	$5\frac{3}{8}$	1.04	1.53	2.02	3.01	4.01
.46	$5\frac{1}{2}$	1.07	1.58	2.09	3.11	4.14
.47	$5\frac{5}{8}$	1.11	1.63	2.16	3.21	4.28
.48	$5\frac{3}{4}$	1.15	1.68	2.23	3.32	4.41
.49	$5\frac{7}{8}$	1.18	1.74	2.30	3.42	4.55
.50	6	1.22	1.79	2.37	3.53	4.69
.51	$6\frac{1}{8}$	1.26	1.85	2.44	3.64	4.83
.52	$6\frac{1}{4}$	1.30	1.90	2.51	3.74	4.97
.53	$6\frac{3}{8}$	1.34	1.96	2.59	3.85	5.12
.54	$6\frac{1}{2}$	1.38	2.02	2.66	3.96	5.26
.55	$6\frac{5}{8}$	1.42	2.07	2.74	4.07	5.41
.56	$6\frac{3}{4}$	1.46	2.13	2.81	4.18	5.56
.57	$6\frac{13}{16}$	1.50	2.19	2.89	4.30	5.71
.58	$6\frac{15}{16}$	1.54	2.25	2.97	4.41	5.86
.59	$7\frac{1}{16}$	1.58	2.31	3.05	4.53	6.01
.60	$7\frac{3}{16}$	1.62	2.37	3.13	4.64	6.17
.61	$7\frac{5}{16}$	1.67	2.43	3.20	4.76	6.32
.62	$7\frac{7}{16}$	1.71	2.49	3.28	4.88	6.47
.63	$7\frac{9}{16}$	1.75	2.55	3.37	5.00	6.63
.64	$7\frac{11}{16}$	1.80	2.62	3.45	5.12	6.79
.65	$7\frac{13}{16}$	1.84	2.68	3.53	5.24	6.95
.66	$7\frac{15}{16}$	1.89	2.75	3.61	5.36	7.11
.67	$8\frac{1}{16}$	1.93	2.81	3.70	5.48	7.28
.68	$8\frac{3}{16}$	1.98	2.87	3.79	5.61	7.44
.69	$8\frac{1}{4}$	2.02	2.94	3.87	5.73	7.61
.70	$8\frac{3}{8}$	2.07	3.01	3.95	5.86	7.77
.71	$8\frac{1}{2}$	2.12	3.07	4.04	5.99	7.94
.72	$8\frac{5}{8}$	2.16	3.14	4.13	6.12	8.11
.73	$8\frac{3}{4}$	2.21	3.21	4.22	6.24	8.28
.74	$8\frac{7}{8}$	2.26	3.28	4.31	6.38	8.45
.75	9	2.31	3.35	4.40	6.51	8.62
.76	$9\frac{1}{8}$	2.36	3.42	4.49	6.64	8.80
.77	$9\frac{1}{4}$	2.41	3.49	4.58	6.77	8.97
.78	$9\frac{3}{8}$	2.46	3.56	4.67	6.90	9.15
.79	$9\frac{1}{2}$	2.51	3.63	4.76	7.04	9.33
.80	$9\frac{5}{8}$	2.56	3.70	4.85	7.18	9.51
.81	$9\frac{3}{4}$	2.61	3.77	4.95	7.31	9.69
.82	$9\frac{13}{16}$	2.66	3.84	5.04	7.45	9.87
.83	$9\frac{15}{16}$	2.71	3.92	5.14	7.59	10.05
.84	$10\frac{1}{16}$	2.77	3.99	5.23	7.73	10.23
.85	$10\frac{3}{16}$	2.82	4.07	5.33	7.87	10.42
.86	$10\frac{5}{16}$	2.87	4.14	5.43	8.01	10.60
.87	$10\frac{7}{16}$	2.93	4.22	5.52	8.15	10.79
.88	$10\frac{9}{16}$	2.98	4.29	5.62	8.30	10.98
.89	$10\frac{11}{16}$	3.04	4.37	5.72	8.44	11.17
.90	$10\frac{13}{16}$	3.09	4.45	5.82	8.59	11.36
.91	$10\frac{15}{16}$	3.15	4.53	5.92	8.73	11.55
.92	$11\frac{1}{16}$	3.20	4.60	6.02	8.88	11.74
.93	$11\frac{3}{16}$	3.26	4.68	6.13	9.03	11.94
.94	$11\frac{1}{4}$	3.32	4.76	6.23	9.17	12.13
.95	$11\frac{3}{8}$	3.37	4.84	6.33	9.32	12.33
.96	$11\frac{1}{2}$	3.43	4.92	6.44	9.48	12.53
.97	$11\frac{5}{8}$	3.49	5.00	6.55	9.62	12.72
.98	$11\frac{3}{4}$	3.55	5.09	6.64	9.78	12.92
.99	$11\frac{7}{8}$	3.61	5.17	6.75	9.93	13.12
1.00	12	3.67	5.25	6.86	10.08	13.32
1.01	$12\frac{1}{8}$	......	5.33	6.96	10.24	13.53
1.02	$12\frac{1}{4}$	......	5.42	7.07	10.40	13.73
1.03	$12\frac{3}{8}$	......	5.50	7.18	10.55	13.94
1.04	$12\frac{1}{2}$	......	5.59	7.29	10.71	14.15
1.05	$12\frac{5}{8}$	......	5.67	7.40	10.87	14.35
1.06	$12\frac{3}{4}$	......	5.76	7.51	11.03	14.56
1.07	$12\frac{13}{16}$	......	5.84	7.62	11.18	14.76
1.08	$12\frac{15}{16}$	......	5.93	7.73	11.35	14.98
1.09	$13\frac{1}{16}$	......	6.02	7.84	11.51	15.19
1.10	$13\frac{3}{16}$	......	6.11	7.96	11.68	15.41
1.11	$13\frac{5}{16}$	......	6.20	8.07	11.84	15.62
1.12	$13\frac{7}{16}$	......	6.29	8.18	12.00	15.84
1.13	$13\frac{9}{16}$	......	6.37	8.29	12.16	16.04
1.14	$13\frac{11}{16}$	......	6.46	8.41	12.33	16.26
1.15	$13\frac{13}{16}$	......	6.56	8.53	12.50	16.48
1.16	$13\frac{15}{16}$	......	6.65	8.65	12.67	16.70
1.17	$14\frac{1}{16}$	......	6.74	8.76	12.84	16.93
1.18	$14\frac{3}{16}$	......	6.83	8.88	13.01	17.15
1.19	$14\frac{1}{4}$	......	6.93	9.10	13.18	17.37
1.20	$14\frac{3}{8}$	......	7.02	9.12	13.35	17.59
1.21	$14\frac{1}{2}$	......	7.11	9.24	13.52	17.81
1.22	$14\frac{5}{8}$	......	7.20	9.36	13.69	18.03
1.23	$14\frac{3}{4}$	......	7.30	9.48	13.87	18.27
1.24	$14\frac{7}{8}$	......	7.40	9.60	14.04	18.49
1.25	15	......	7.49	9.72	14.21	18.71
1.26	$15\frac{1}{8}$	......	......	......	14.39	18.95
1.27	$15\frac{1}{4}$	......	......	......	14.56	19.17
1.28	$15\frac{3}{8}$	......	......	......	14.74	19.41
1.29	$15\frac{1}{2}$	......	......	......	14.92	19.65
1.30	$15\frac{5}{8}$	......	......	......	15.11	19.88
1.31	$15\frac{3}{4}$	......	......	......	15.29	20.12
1.32	$15\frac{13}{16}$	......	......	......	15.46	20.34
1.33	$15\frac{15}{16}$	......	......	......	15.64	20.58
1.34	$16\frac{1}{16}$	......	......	......	15.82	20.82
1.35	$16\frac{3}{16}$	......	......	......	16.01	21.06
1.36	$16\frac{5}{16}$	......	......	......	16.19	21.29
1.37	$16\frac{7}{16}$	......	......	......	16.37	21.53
1.38	$16\frac{9}{16}$	......	......	......	16.57	21.78
1.39	$16\frac{11}{16}$	......	......	......	16.75	22.02
1.40	$16\frac{13}{16}$	......	......	......	16.94	22.27
1.41	$16\frac{15}{16}$	......	......	......	17.13	22.51
1.42	$17\frac{1}{16}$	......	......	......	17.31	22.75
1.43	$17\frac{3}{16}$	......	......	......	17.51	23.01
1.44	$17\frac{1}{4}$	......	......	......	17.70	23.26
1.45	$17\frac{3}{8}$	......	......	......	17.89	23.50
1.46	$17\frac{1}{2}$	......	......	......	18.08	23.75
1.47	$17\frac{5}{8}$	......	......	......	18.28	24.01
1.48	$17\frac{3}{4}$	......	......	......	18.47	24.26
1.49	$17\frac{7}{8}$	......	......	......	18.66	24.50
1.50	18	......	......	......	18.85	24.75

90° TRIANGULAR-NOTCH WEIRS.

This type of weir deserves to be more widely used than at present for the measurement of small quantities of water to the irrigator. If the fall is available it may be used for flows as great as 14 second-feet, which would be obtained with a depth of practically 2 feet of water above the vertex, or lowest point, of the angle formed by the sides. However, conditions usually are not favorable for its use for such large heads, and Table 7 gives the discharge for heads up to 1.25 feet. Since the sides meet at a point with no length of crest, a small flow of water that would not pass over one of the other weirs without adhering to the crest and therefore making the measurement worthless, will flow free in the 90° triangular notch and may be measured accurately. The 90° triangular notch is especially applicable from the smallest flow up to 2 or 3 cubic feet per second. Because of the greater depth of water required for this type of weir to discharge a given quantity of water, and the consequent greater loss of grade, one of the other types of weirs usually will be better adapted to large quantities of water.

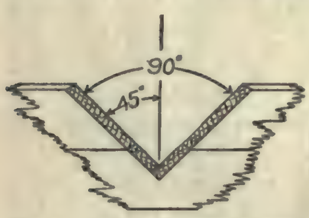

FIG. 5.—Ninety-degree triangular notch weir.

Experiments have shown that the rectangular and Cipolletti weirs with 6-inch crest lengths do not follow the same laws of discharge as the longer weirs, and the discharge formulas given in this bulletin for these weirs do not apply to weirs with a crest length of 6 inches. Therefore, where only a small flow of water is to be measured the use of the 90° triangular notch is especially recommended.

The sides of the 90° triangular notch may be set readily by means of a carpenter's square and level. The notch can be marked out properly by placing the point of the angle between the arms of a carpenter's square at a point which is to be the bottom of the notch and adjusting the square so that the same figures on both arms of the square are at the edge of the board, then if the board is set level the notch will be in the proper position. The sides, therefore, have the same slope.

Table 7 gives the discharge over the 90° triangular notch, computed from the corrected formula.

TABLE 7.—*Discharge table for 90° triangular notch.*

Computed from the formula $Q=2.49\ H^{2.48}$.

Head in feet.	Head in inches.	Discharge in second-feet (Q).	Head in feet.	Head in inches.	Discharge in second-feet (Q).	Head in feet.	Head in inches.	Discharge in second-feet (Q).
0.20	$2\frac{3}{8}$	0.046	0.55	$6\frac{5}{8}$	0.564	0.90	$10\frac{13}{16}$	1.92
.21	$2\frac{1}{2}$	.052	.56	$6\frac{3}{4}$	.590	.91	$10\frac{15}{16}$	1.97
.22	$2\frac{5}{8}$	.058	.57	$6\frac{13}{16}$	.617	.92	$11\frac{1}{16}$	2.02
.23	$2\frac{3}{4}$	.065	.58	$6\frac{15}{16}$	.644	.93	$11\frac{3}{16}$	2.08
.24	$2\frac{7}{8}$	.072	.59	$7\frac{1}{16}$	.672	.94	$11\frac{1}{4}$	2.13
.25	3	.080	.60	$7\frac{3}{16}$	.700	.95	$11\frac{3}{8}$	2.19
.26	$3\frac{1}{8}$	.088	.61	$7\frac{5}{16}$	.730	.96	$11\frac{1}{2}$	2.25
.27	$3\frac{1}{4}$	.096	.62	$7\frac{7}{16}$	.760	.97	$11\frac{5}{8}$	2.31
.28	$3\frac{3}{8}$	.106	.63	$7\frac{9}{16}$	.790	.98	$11\frac{3}{4}$	2.37
.29	$3\frac{1}{2}$	.115	.64	$7\frac{11}{16}$	.822	.99	$11\frac{7}{8}$	2.43
.30	$3\frac{5}{8}$	.125	.65	$7\frac{13}{16}$	.854	1.00	12	2.49
.31	$3\frac{3}{4}$	.136	.66	$7\frac{15}{16}$	.887	1.01	$12\frac{1}{8}$	2.55
.32	$3\frac{13}{16}$	.147	.67	$8\frac{1}{16}$	.921	1.02	$12\frac{1}{4}$	2.61
.33	$3\frac{15}{16}$	.159	.68	$8\frac{3}{16}$	.955	1.03	$12\frac{3}{8}$	2.68
.34	$4\frac{1}{16}$	.171	.69	$8\frac{1}{4}$	.991	1.04	$12\frac{1}{2}$	2.74
.35	$4\frac{3}{16}$	.184	.70	$8\frac{3}{8}$	1.03	1.05	$12\frac{5}{8}$	2.81
.36	$4\frac{5}{16}$	.197	.71	$8\frac{1}{2}$	1.06	1.06	$12\frac{3}{4}$	2.87
.37	$4\frac{7}{16}$	.211	.72	$8\frac{5}{8}$	1.10	1.07	$12\frac{13}{16}$	2.94
.38	$4\frac{9}{16}$	.226	.73	$8\frac{3}{4}$	1.14	1.08	$12\frac{15}{16}$	3.01
.39	$4\frac{11}{16}$	.240	.74	$8\frac{7}{8}$	1.18	1.09	$13\frac{1}{16}$	3.08
.40	$4\frac{13}{16}$	.256	.75	9	1.22	1.10	$13\frac{3}{16}$	3.15
.41	$4\frac{15}{16}$	.272	.76	$9\frac{1}{8}$	1.26	1.11	$13\frac{5}{16}$	3.22
.42	$5\frac{1}{16}$	.289	.77	$9\frac{1}{4}$	1.30	1.12	$13\frac{7}{16}$	3.30
.43	$5\frac{3}{16}$	.306	.78	$9\frac{3}{8}$	1.34	1.13	$13\frac{9}{16}$	3.37
.44	$5\frac{1}{4}$	.324	.79	$9\frac{1}{2}$	1.39	1.14	$13\frac{11}{16}$	3.44
.45	$5\frac{3}{8}$	.343	.80	$9\frac{5}{8}$	1.43	1.15	$13\frac{13}{16}$	3.52
.46	$5\frac{1}{2}$	.362	.81	$9\frac{3}{4}$	1.48	1.16	$13\frac{15}{16}$	3.59
.47	$5\frac{5}{8}$	.382	.82	$9\frac{13}{16}$	1.52	1.17	$14\frac{1}{16}$	3.67
.48	$5\frac{3}{4}$	.403	.83	$9\frac{15}{16}$	1.57	1.18	$14\frac{3}{16}$	3.75
.49	$5\frac{7}{8}$	.424	.84	$10\frac{1}{16}$	1.61	1.19	$14\frac{1}{4}$	3.83
.50	6	.445	.85	$10\frac{3}{16}$	1.66	1.20	$14\frac{3}{8}$	3.91
.51	$6\frac{1}{8}$	.468	.86	$10\frac{5}{16}$	1.71	1.21	$14\frac{1}{2}$	3.99
.52	$6\frac{1}{4}$	.491	.87	$10\frac{7}{16}$	1.76	1.22	$14\frac{5}{8}$	4.07
.53	$6\frac{3}{8}$	.515	.88	$10\frac{9}{16}$	1.81	1.23	$14\frac{3}{4}$	4.16
.54	$6\frac{1}{2}$	.539	.89	$10\frac{11}{16}$	1.86	1.24	$14\frac{7}{8}$	4.24
						1.25	15	4.33

UNITS OF MEASURE.

The *cubic-foot per second*, called second-foot, is a unit of measure for flowing water. When a stream discharges 1 cubic foot of water in one second there is a second-foot flow.

The *acre-foot* is a unit of measure for standing water, and is that volume which will cover 1 acre 1 foot deep. An acre-inch is $\frac{1}{12}$ of an acre-foot, or the volume which will cover 1 acre to a depth of 1 inch.

The *miner's inch* is unsatisfactory and rapidly losing favor as a unit for measuring water, because it is not a definite quantity. It varies with the conditions under which it is used, and therefore is being replaced by the second-foot. In several of the Western States the miner's inch has been defined by law as being a certain fractional part of a second-foot, and these values are given in the accompanying table of hydraulic equivalents.

TABLE OF HYDRAULIC EQUIVALENTS.

1 cubic foot equals 7.48 gallons, or approximately 7½ gallons.
1 cubic foot of water weighs approximately 62½ pounds.
1 cubic foot per second equals 448.83 gallons per minute, or approximately 450 gallons per minute.
1 cubic foot per second flowing for 1 hour equals approximately 1 acre-inch.
1 cubic foot per second flowing for 12 hours equals appromiately 1 acre-foot.
1 cubic-foot per second flowing for 24 hours equals approximately 2 acre-feet.
1 acre-foot equals 43,560 cubic feet, equals 325,851 gallons.
1,000,000 cubic feet equals 22.95 acre-feet.

In California, Nevada, and Montana 1 miner's inch (statutory inch) equals $\frac{1}{40}$ of 1 cubic foot per second.

In Utah, Idaho, and Arizona 1 miner's inch (statutory inch) equals $\frac{1}{50}$ of 1 cubic foot per second.

In Colorado it is generally assumed that 1 miner's inch (statutory inch) equals 1/38.4 of 1 cubic foot per second.

SOME PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO IRRIGATION.

AVAILABLE FOR FREE DISTRIBUTION.

Wood Pipe for Conveying Water for Irrigation (Department Bulletin 155).
Irrigation in Florida (Department Bulletin 462).
Spray Irrigation (Department Bulletin 494).

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

How to Build Small Irrigation Ditches (Farmers' Bulletin 158). Price, 5 cents.
Use of Alcohol and Gasoline in Farm Engines (Farmers' Bulletin 277). Price, 5 cents.
Practical Information for Beginners in Irrigation (Farmers' Bulletin 263). Price, 5 cents.
Irrigation of Alfalfa (Farmers' Bulletin 373). Price, 5 cents.
Irrigation of Sugar Beets (Farmers' Bulletin 392). Price, 5 cents.
Use of Windmills in Irrigation in Semiarid West (Farmers' Bulletin 394). Price, 5 cents.
Irrigation of Grain (Farmers' Bulletin 399). Price, 5 cents.
Irrigation of Orchards (Farmers' Bulletin 404). Price, 5 cents.
Irrigation Practice in Rice Growing (Farmers' Bulletin 673). Price, 5 cents.
Progress Report of Cooperative Irrigation Experiments at California University Farm, Davis, Cal., 1909–1912 (Department Bulletin 10). Price, 5 cents.
Gate Structures for Irrigation Canals (Department Bulletin 115). Price, 20 cents.
Concrete Lining as Applied to Irrigation Canals (Department Bulletin 126). Price, 10 cents.
Flow of Water in Irrigation Channels (Department Bulletin 194). Price, 25 cents.
The Flow of Water in Wood-stave Pipe (Department Bulletin 376). Price 25 cents.
Delivery of Water to Irrigators (Office of Experiment Stations Bulletin 229). Price, 15 cents.
Use of Underground Water for Irrigation at Pomona, Cal. (Office of Experiment Stations Bulletin 236). Price, 20 cents.
Irrigation in San Joaquin Valley, Cal. (Office of Experiment Stations Bulletin 239). Price, 15 cents.

BERMUDA GRASS

SAMUEL M. TRACY
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FARMERS' BULLETIN 814

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. May, 1917

BERMUDA grass is the most important perennial grass in the Southern States. It was introduced into the United States at least as early as 1806.

Besides the common Bermuda grass, there are several varieties, the most important of which are the Giant, characterized by a very large growth, and St. Lucie grass, similar to ordinary Bermuda grass, but lacking underground rootstocks.

Bermuda grass grows well mixed with lespedeza for a summer crop. Bur clover, black medic, and hairy vetch as winter crops alternate well with it.

The best Bermuda-grass pastures of the South will usually carry two head of cattle per acre for eight months of the year. On poor soils the carrying capacity is not more than one cow per acre.

On rich bottom land Bermuda grass grows tall enough to cut for hay. Under exceptional circumstances three or more cuttings may be secured in a season, giving total yields of from 6 to 10 tons of hay per acre. It will grow well on soils so alkaline that most other field crops, as well as fruits, will fail.

The feeding value of Bermuda-grass hay compares closely with that of timothy hay.

Bermuda grass frequently is used to bind levees and to prevent hillsides from washing.

The grass usually can be eradicated by growing two smother crops, a winter one of oats or rye, followed by a summer crop of cowpeas or velvet beans.

BERMUDA GRASS.

CONTENTS.

	Page.		Page.
Introduction	3	Pasture value	10
Description of Bermuda grass	3	Bermuda grass for hay	13
History	4	Bermuda grass for turf	13
Climatic adaptations	5	Bermuda grass for soil binding	14
Adaptations to soil	5	Market value	14
Distribution in the United States	6	Feeding value	15
Varieties	7	Eradication	18
Seed production	8	Summary	18
Propagation	8		

INTRODUCTION.

Bermuda grass[1] is the most common and most valuable pasture plant in all the Southern States, being of the same relative importance in that region that Kentucky bluegrass is in more northern States. In many sections of the South it is one of the best grasses for hay, and it is the most common grass used for lawn purposes.

It makes a vigorous and persistent growth in nearly all the warmer parts of the world, and its value depends on the region in which it is grown and the purpose for which it is to be used. In India it is known as sacred grass and is there believed to have been the gift of some benevolent deity for the support of the cows, which are also held as sacred in that country. In sharp contrast with that, however, in the southwestern part of the United States it is known as devil grass on account of the trouble which it gives in irrigated fields and on ditch banks.

DESCRIPTION OF BERMUDA GRASS.

Bermuda grass is a perennial, spreading by runners or by rootstocks, or by both, and also by seeds. The runners are usually from a few inches to 3 or 4 feet, though sometimes more than 20 feet in length, creeping over the surface of the ground and often rooting at the joints. The erect flower-bearing branches are usually 6 to 12 inches in height, though reaching 2 feet or more in some varieties; the leaf blades are narrow, flat, 1 to 4 inches in length, each bearing a ring of minute white hairs at the base; the flowers are in slender spikes, three to six in a cluster, radiating like those of crab-grass, each spike 1 to 2 inches long. (Fig. 1.)

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[1] *Cynodon dactylon* or *Capriola dactylon.*

The stems of this grass are peculiar in that they often appear to have from two to four leaves at each joint. There is really only one leaf at each joint, but in many cases two to four contiguous joints are very short and so bear as many leaves close together as there are short joints. The two or more short joints are succeeded by a longer joint, 1 to 3 inches in length, which, in turn, may be followed by two or more short joints. While this arrangement of alternating long and short joints is very common, it is far from being uniform.

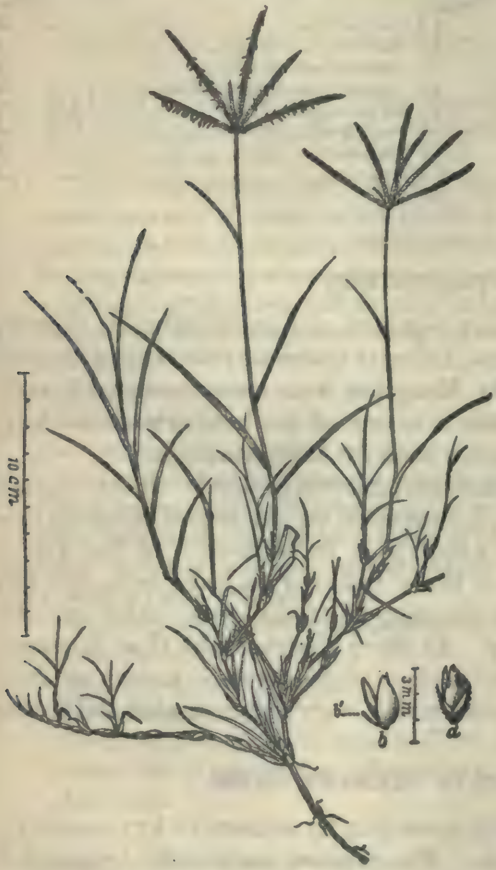

FIG. 1.—Bermuda grass.

HISTORY.

Bermuda grass is undoubtedly a native of the Old World, probably of India, but it is now common in all tropical and subtropical parts of the world. It is not known when it made its first appearance in America, but in Mease's Geological Account of the United States, published in 1807, it is mentioned as one of the most important grasses in the Southern States. It is now common in all parts of the United States from Virginia to Florida and westward to Arizona and California.

In the United States it is commonly known as Bermuda grass, which suggests that it may have come to America by way of the islands of that name, though there is no definite published record of such a source. In some localities it is known as wire-grass, scutch-grass, dog's-tooth, or Bahama grass, and in California and Arizona it is often called devil grass. In Australia it is commonly known as couch or Indian couch. In the Hawaiian Islands it is known as manienie, while in India it is called doob, and in southern India hariali. The many names which have been given to it in different parts of the world show that it has a wide distribution and that it has long been regarded as an important plant.

There is a grass which is often called "water Bermuda" or "ditch Bermuda."[1] It is better known as knot-grass, or ditch-grass, as it commonly grows on the sides and bottoms of ditches and on other damp soils, where it gives a considerable amount of grazing but is of no value for hay. It is easily distinguished from true Bermuda grass, which has three to six seed spikes, while this has but two.

CLIMATIC ADAPTATIONS.

Bermuda grass requires warm weather during its growing season. It bears intense summer heat without injury, but is seriously injured by a moderate degree of cold and is seldom persistent where the temperature often falls much below zero F., though the rootstocks may withstand a somewhat lower temperature. It often winterkills in western Kentucky and Tennessee. It usually does not bear heavy freezing, though it has lived through a temperature of $-10°$ F. in Kentucky and in Washington, D. C., and $-18°$ F. in Oklahoma. On the Atlantic coast, southeastern Virginia is about the northern limit of its profitable growth, and there it is not sufficiently aggressive to interfere with the growth of alfalfa. On the Pacific coast it makes little growth north of California.

Bermuda grass does best with abundant moisture, but will not grow well where the ground is not thoroughly drained. In the arid region of the Southwest it is of little value if not irrigated, not making as vigorous a growth as curly mesquite, buffalo grass, and some other native species. It bears a long and hot summer with little injury, though it makes little growth when the weather is very dry and it is not irrigated. It will bear flooding for some weeks, but will not grow well where the soil is constantly saturated with stagnant water.

It does not bear shading well, even when all other conditions are favorable, and planters often take advantage of this fact to secure its eradication by growing smother crops.

ADAPTATIONS TO SOIL.

Bermuda grass will grow well on almost any soil which is fertile and not too wet, but better on soils that are heavy than on those which are light and sandy. On the latter it is likely to be crowded out by carpet grass or other native species. It will grow satisfactorily on light and sandy soils when they are well fertilized with cottonseed meal, dried blood, or some other nitrogenous fertilizer, but it does not do well on soils containing little humus or nitrogen. It will grow well on soils so alkaline that most other field crops, as well as fruits, will fail, as has been shown in California and other Southwestern States. The presence or absence of lime seems to have little effect on the amount of its growth. Careful trials at the Mississippi and Georgia agricultural experiment stations have shown no beneficial effects from the application of lime in any form, though similar tests at the Tennessee station have indicated a moderate benefit. While the presence or absence of lime may not influence the yield, it apparently influences the quality. Live-stock dealers and butchers in Mobile and New Orleans have stated repeatedly that they can recognize cattle that have been raised in a limestone region and that these cattle always bring the highest price.

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[1] *Paspalum distichum.*

Bermuda grass does best on a fertile soil which is fairly moist, well drained, and rich in humus and nitrogen.

DISTRIBUTION IN THE UNITED STATES.

The accompanying map (fig. 2) shows approximately the region in which Bermuda grass has become naturalized and is more or less profitable. The shaded portion marks the region where the grass is grown most extensively. In warm valleys and specially favorable locations it often grows for some distance north of the limit shown. Bermuda grass grows well in many parts of California, but is utilized there mainly for lawns, rarely for hay or pasture. It is often a troublesome weed in alfalfa fields and is objectionable on the banks of irrigation ditches, as its runners often spread so as to obstruct the flow of water. East of the one hundredth meridian the northern limit of its profitable growth is about the same as the southern limit for the growth of Kentucky bluegrass, though in many places the ground is occupied by a more or less uneven mixture of the two. It is not common north of the Potomac and Ohio Rivers or north of the Missouri River east of Kansas City.

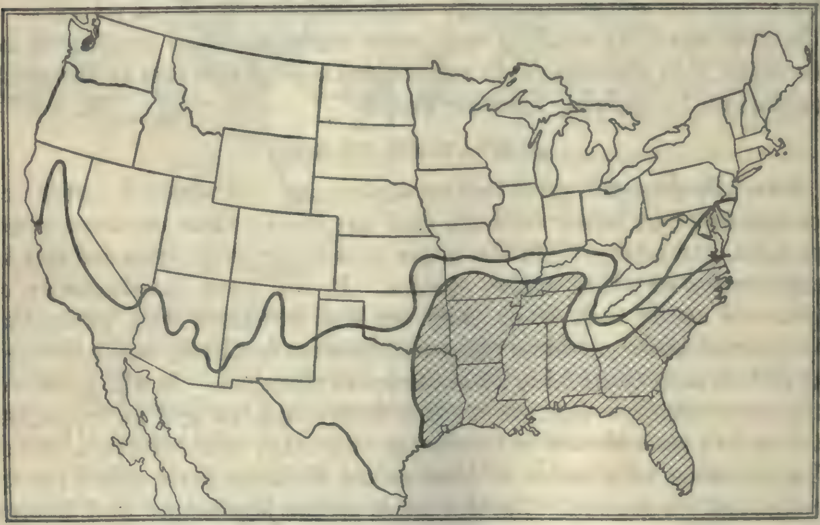

FIG. 2.—Map of the United States, showing the distribution of Bermuda grass. The upper line indicates its northern limit, but the grass is of most value in the shaded area.

VARIETIES.

Bermuda grass is valued principally for two purposes—for the production of hay and pasture and for use on lawns. For hay and pasture the best variety is that which makes the strongest growth, while for lawns the most satisfactory is one which is dwarf in growth and covers the ground with a dense mat of turf. For use in the northern parts of the Bermuda-grass region the variety planted for any purpose should be one which is not killed by ordinary freezes, while the ability to resist cold needs less consideration farther south. The variety to be planted should be selected to suit the purpose and locality for which it is wanted.

The soil on which Bermuda grass is grown and the treatment which it receives cause great variations in its growth. Plants which may make a rank, erect growth, a foot or more in height and with long leaves, when grown on a rich and moist soil may make only a flat and spreading growth, with stems only 2 or 3 inches high and with very short leaves, when transplanted to a hard clay soil. There are, however, a few varieties which are quite distinct from others wherever they may be planted.

The most common variety, the one which is in almost universal use wherever Bermuda grass is grown, produces stems only about a foot or less in height, though varying greatly. It produces abundant rootstocks, which often run several inches below the surface of the ground, and also makes surface runners, which may be from a few inches to several feet in length.

The most rank-growing sort yet found is Giant Bermuda grass,[1] introduced from Brazil a few years ago. On a rich and moist soil it often makes runners 20 feet or more in length, with an abundance of erect stems 2 feet or more in height, affording two or three annual cuttings and yielding more than any other variety yet tested. It rarely produces seed heads and has few or no underground rootstocks. Another form from southern Florida is very similar in growth, but has shorter runners and produces seed heads very abundantly. While both these varieties make heavy yields for hay and grazing, they are too coarse for use on a lawn. St. Lucie grass is another variety, with no underground rootstocks. This variety is rather dwarf in growth, seldom more than 6 inches in height, with slender stems and small leaves. It is one of the best sorts for lawns and dooryards. It is common in Florida and is not hardy as far north as middle Georgia. Its growth is too dwarf to make it profitable for hay, but it recovers quickly after frosts and so is valuable for pastures and lawns.

Many other varieties may be separated from the common Bermuda grass of the fields, the most important differences being in rankness of growth, the presence or absence of underground rootstocks, hardiness, and other characters of less importance. When it is desired to propagate any peculiar form which may be found, the plants should be increased by the division of the runners or rootstocks, as seeds rarely produce exact duplicates of the parent form.

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[1] *Cynodon dactylon* var. *maritimus*.

There seems to be little relation between the growth of rootstocks underground and the growth of the stems above ground. In general, however, those varieties making deep underground rootstocks stand more severe freezes than those with only surface runners and so are more desirable for planting in the northern part of the Bermuda-grass region. The varieties with only surface runners are more easily killed when it is desired to exterminate the grass and use the land for other crops.

SEED PRODUCTION.

Bermuda grass seeds freely in southern California, Arizona, and New Mexico, and from these States part of the commercial supply of seed is now obtained. Tests of seeds grown in California and Arizona have shown a germination of 95 per cent, which is a much higher percentage than is obtained from most imported seed. Many years ago all the seed used in this country was imported from Australia and sold at a very high price, but now that home-grown seed has proved fully as good the price has steadily declined until seed may be bought for about 50 cents a pound.

Bermuda grass also seeds occasionally much farther east, good seed having been found in southern Texas, southwestern Louisiana, North Carolina, and even as far north as Washington, D. C. It does not seed well in any region of heavy rainfall, as on the Gulf coast, and it needs a season of considerable heat and dry weather for the best seed development. It is probable that the occasional development of seed is an important factor in the spread of the grass in all parts of the country where it occurs.

PROPAGATION.

Bermuda grass may be propagated either by seeds or by "roots" or cuttings.

As the seeds are very light and small, the ground should be put in the finest possible condition before they are sown. The sowing should not be done until late in the spring, when the soil has become fairly warm. Immediately after cotton planting is generally the best season for the work. When good seed is used 5 pounds per acre are sufficient. Before sowing, it should be mixed with cottonseed meal, wood ashes, or some similar material—even fine soil will answer—to increase the bulk and so secure a more even distribution over the field. The seeding should always be broadcast and can be done either by hand or by using a wheelbarrow seeder. In any case it is better to sow only half the seed the first time the field is gone over, and then the other half while going over the field at right angles to the direction in which the first half was sown, so as to cover skips and balks. If possible, a roller should be used for covering the seeds, but if that is not available a light smoothing harrow or a drag made of brush may be employed. The covering should always be very shallow; therefore the use of a roller is of great advantage, as it packs and firms the soil without covering the seeds too deeply.

When the seed is planted in the spring on well-prepared soil, the plants will cover the ground by midsummer and will give a cutting for hay or a considerable amount of pasturage in the fall. It is useless to plant seed on poorly prepared land. Ground seeded in the spring should not be pastured until the sod has become so dense that it will not be injured by trampling. When bare spots are found they can be filled in easily by transplanting "roots" from the thicker places at any time during the summer.

Roots and cuttings are used in propagation much more commonly than seeds. In planting, fresh sods about an inch in thickness should be taken up, either by using a spade or a plow, and then torn into very small pieces for distribution. It is common practice to plow furrows 4 to 6 feet apart, then drop pieces of sod every 2 or 3 feet and cover with the foot. This method of planting is very inexpensive and answers well where the land is to be used as a pasture, but it leaves the surface of the ground too rough and uneven for a good meadow. When the entire surface is plowed, the pieces may be dropped 2 or 3 feet apart and pushed into the soil with a forked stick, such as is used in planting sweet potatoes, and then stepped on, to firm the soil and prevent drying out.

Another method is to plow the old sod very shallow, harrow until the roots are well loosened, rake into piles or windrows, and load into a wagon. The wagon is then driven across the freshly prepared field in which the planting is to be done and the roots dropped about 2 feet apart in the wheel tracks and covered with the foot. The ground should be gone over twice, lapping the spaces, so that the rows will be only half as far apart as the distance between the wheels. An ordinary wagon box will hold enough roots to plant 1 to 2 acres, depending on how finely the roots are divided and how carefully the work is done. When planted in this way the grass will cover the ground in a few weeks and the total expense, including the preparation of the ground, need not be more than $5 per acre for the labor employed.

When a field is to be planted for a meadow it should be prepared as carefully as for seeding. Since it is to be a permanent field for mowing and will be used many years for that purpose, all bumps and hollows should be smoothed off, so that water can not stand in low spots and the mowing machine and rake may run over it smoothly and not be injured by racking. While Bermuda grass will make some sort of a growth in almost any field it can never make a satisfactory meadow if the ground is not well prepared and made smooth before planting. As good soil and as thorough preparation are needed to make a good meadow as to make a good crop of corn or cotton.

When roots are used for planting they should always be protected from the sun as much as possible. When loaded into a wagon they should be wet down and covered with a blanket or old sacks to prevent them from becoming dry.

As is stated elsewhere, different varieties of Bermuda grass vary greatly in hardiness. Some are killed by very moderate frosts, while others, usually those with deep-running rootstocks, bear heavy freezes without injury. For this reason it is safer in the northern parts of the Bermuda region to propagate from near-by old fields, as these plants have proved themselves hardy. While seeds may make an abundance of thrifty plants, many of them are likely to be killed by the first severe winter. Farther south, seeds may be used with greater safety.

Whatever method may be followed in planting it will often be necessary to mow the field a few weeks afterwards to prevent weeds from shading and choking out the young Bermuda-grass plants.

PASTURE VALUE.

Bermuda grass is the foundation of all good permanent pastures in the South. It is the best pasture grass in the region from the Carolinas westward to California on soils of fair fertility and with even moderate rainfall, although on the very dry lands of New Mexico and Arizona it is less productive than curly mesquite and buffalo grasses. It bears heavy grazing and trampling with little injury, recovers quickly when grazed down, and is eaten greedily by all kinds of live stock. Even the rootstocks are so tender and juicy that they are well liked by hogs. It should be used as the principal grass in the making of all permanent pastures in the region shaded in figure 2, and should be supplemented by whatever other grazing plants grow well in each special locality.

As it is killed to the ground by the first severe frost, it usually gives good grazing only through the summer and fall months, though in the southern portions of Florida and Texas it frequently remains green and gives good feed through the entire year. In California it furnishes good grazing about nine months. In Oklahoma it is green from April to October. In Virginia Bermuda grass and lespedeza give the best grazing on the low lands. On sandy soils Bermuda grass does not bear trampling and close grazing as well as on heavier soils. When used for pasture it should be kept closely grazed. If the stems are allowed to become too old they get so dry and wiry that live stock do not relish them. Where there is not sufficient live stock in the pasture to keep the grass well grazed down it will often pay to harvest for hay and so secure a fresh growth for pasturing, which is more palatable and more nutritious than the older stems.

The number of live stock which can be carried on an acre of Bermuda-grass pasture varies widely with the soil and climate. On average soils such pasture will carry about one steer to the acre during the growing season, though on thin and hard clay soils as much as 2 acres per steer may be required. In specially favorable localities in the extreme south on very fertile soils 1 acre of Bermuda-grass pasture may support three or four steers nine or ten months. The Mississippi Agricultural Experiment Station says this pasture will support at least one steer per acre on ordinary soils and double that number on soils more favorable for its growth. On the rich alluvial soils formed by the overflows of the Mississippi River the growth of the grass is much more rank, some cattle growers in that region claiming that they can graze as many as six steers per acre for nine months and that the pastures will then support one to three steers per acre during the other three months. Of course, such yields are very exceptional and should not be considered in estimating the value of Bermuda grass on ordinary soils.

Bermuda grass does not mix well with other grasses, as it either makes a clean sod by itself or is crowded out by other plants better suited to the particular locality. This is especially true on the rather sandy lands along the coast where carpet grass is abundant. There the sod is often spotted, the heavier and richer spots where a stump has been removed or a little fertilizer dropped being densely covered with Bermuda grass, while adjacent spots may be covered with an equally dense mat of carpet grass. Whenever it is planted on a soil suited to its growth, Bermuda grass will crowd out most other grasses and soon occupy the entire field, but the crowding out is usually in very definite areas and not by a gradual mixing.

There are, however, a few legumes which grow well when planted on the same ground with Bermuda grass and add largely to its pasture value. Among the best of these are lespedeza, bur clover, black medic, and melilotus. Lespedeza grows only in the summer and fall, bur clover and black medic only in the winter and spring, while melilotus gives more or less grazing through the entire year.

Lespedeza is the most valuable species for summer and fall grazing and is the best legume which can be used on fairly heavy soils, but it makes only a weak growth on the sandy soils in the piny woods region. It grows well on clay soils which are too dry and hard for most other legumes.

Bur clover makes its growth in winter and spring and does well on soils which are quite sandy, and even those which contain little lime. It begins its growth in the fall, soon after the Bermuda grass has been cut by frosts, and ripens its seed and disappears at about the time the grass begins its growth in the spring, so it is practically an alternating crop. It makes excellent grazing for hogs and calves, but is of less value for grown cattle and is not eaten readily by mules and horses until after the seed begins to ripen. A combination of bur clover and Bermuda grass is one of the best successions for a permanent pasture for hogs and calves, as it furnishes good grazing throughout most or all of the year.

Black medic has proved of decided value for growing with Bermuda grass in northern Alabama, Mississippi, and Louisiana, and its use is being rapidly extended to other sections. Its growth is not as rank as that of bur clover, but it gives grazing both earlier and later in the season and is eaten more readily by cattle and mules. It grows larger on clayey than on sandy soils and is better adapted to the hardwood region than to that of the piny woods.

These three legumes are all annuals, but reseed the ground freely and so need be planted in pastures but once.

Melilotus usually does not bloom until the second season, but in every field there will be a few plants which produce seeds the first year. Many of the seeds of the original sowing do not germinate until the second season, so the crop is practically continuous and needs to be planted but once. Melilotus grows taller and coarser than the other legumes mentioned, but will thrive on soils too thin and barren for the others, provided it is rich in lime. If lime is plentiful it will grow well on very thin and barren spots where the Bermuda grass will make only a weak growth. It has an unusually large and powerful taproot, and after having been grown on a hard soil a few years causes the soil to become so mellowed and so enriched by the nitrogen and humus left by the decay of the roots that the land is more easily cultivated and more productive. As the soil is brought into a better condition the melilotus gradually disappears and is replaced by a growth of Bermuda grass.

All of these legumes have taproots, which by their quick decay at the end of the season make the soil less compact and by their humus-making and nitrogen-gathering work serve to increase its fertility. At the same time their growth prevents the Bermuda grass from becoming sod bound and so tends to increase the yield of this grass.

Lespedeza and at least one of the other legumes mentioned should be planted in every Bermuda-grass pasture.

BERMUDA GRASS FOR HAY.

The yield of Bermuda grass for hay, as well as for pasture, varies greatly with soil and location. On dry, clay hills at the Mississippi Agricultural Experiment Station, when fertilized with 10 tons of stable manure per acre it has yielded at the rate of 2½ tons per acre. On the black prairie lands of eastern Mississippi and Alabama it yields 1 to 1½ tons per acre at each of two cuttings, while on the rich alluvial lands along the Mississippi and Red Rivers it gives 2 to 3 tons per acre at each of two or three cuttings. The Report of the Oklahoma Agricultural Experiment Station for 1907 records a yield of 11,704 pounds of dry hay per acre, and Prof. J. S. Newman, in Bulletin No. 76 of the South Carolina Agricultural Experiment Station, reports 13,000 pounds of dry hay per acre. In the South Carolina Report for 1888 Dr. St. J. Ravenel mentions a yield of 10 tons per acre. Other growers report equally good or even heavier yields.

In the southern and western parts of its territory and on the immediate Gulf coast, Bermuda grass seldom grows large enough to be profitable for hay, but in the central part of the Southern States it is a valuable and reliable hay plant on all rich and fairly moist soils.

Both meadows and pastures are likely to become somewhat sod bound after having been in Bermuda grass a few years. In pastures this may be almost wholly prevented by planting lespedeza, bur clover, melilotus, or some other legume.

Legumes, however, are less practicable in meadows, and there the sod must be broken up by plowing or disking. Some growers use an ordinary mole subsoil plow for this purpose, running the plow 3 to 4 inches deep and making the furrows about a foot apart. This is very satisfactory, as it loosens the soil and still leaves the surface smooth. A heavy disking will accomplish the same purpose, but should be followed by a smoothing harrow or a heavy roller to smooth the surface.

As long as a meadow or a pasture is giving a satisfactory yield it should not be disturbed.

BERMUDA GRASS FOR TURF.

Bermuda grass makes an excellent sod for lawns and golf grounds, as it forms an even turf without clumps or coarse stems. It is easily kept clipped with a lawn mower, and as it recovers quickly it gives a smooth and even surface. The greatest objection to it for the purpose is that it becomes browned after the first severe frost and so is not attractive in appearance during the winter. That, however, can be easily overcome by seeding the lawn with Italian rye-grass in the early fall. This grass comes up very quickly, bears clipping well, is not injured by frosts, and so keeps the lawn green through the winter. It dies and disappears in the spring at about the time Bermuda grass starts into growth. By using such a mixture it is not difficult to keep the lawn in good condition through the entire year.

White clover may be used in the same way, and as it is a perennial it need be seeded but once. It will add greatly to the freshness of a lawn during the winter and will also improve the growth of the Bermuda grass during the summer.

The character of growth in Bermuda grass varies with its treatment. When kept clipped or grazed closely and trampled heavily the stems become slender, prostrate, and spreading, with numerous short leaves; but when neglected the plants become much coarser, the stems more nearly erect, and the leaves much longer and broader. A good lawn can be made only with constant care.

When Bermuda grass is used for a lawn it is desirable to fertilize liberally with cottonseed meal or ground bone and to water freely. When the grass is used for the putting greens on golf grounds, however, very little fertilizer or water should be applied, since the grass makes a shorter and more satisfactory growth under such treatment.

BERMUDA GRASS FOR SOIL BINDING.

In nearly all the South erosion, or the washing out of gullies on cultivated and hilly lands, is a serious matter, and Bermuda grass is the best plant which has been found to check the damage from this cause. When planted in newly formed or even in old and large gullies it catches the washed-down soil, holds it in place, and soon makes such a growth that the spread of the gully is stopped and at length filled, so that it becomes cultivable ground again. The planting of the grass in newly formed gullies will soon smooth them off. There is no excuse for the formation of destructive and wasteful gullies in any region where Bermuda grass can be grown.

Almost the entire course of the Mississippi River from Cairo southward to the Gulf of Mexico is protected from overflows by a series of levees which have been built with soil from the adjacent lands. These levees must be protected from washing, and Bermuda grass is universally used for the purpose, as its matted rootstocks bind the soil and prevent washing better than any other grass. For this purpose the ordinary variety, producing numerous underground rootstocks, is better than those producing only surface runners.

MARKET VALUE.

The market value of Bermuda hay, like that of all other hays, depends largely on its condition and appearance when offered for sale. The brighter its color and the better the appearance of the bales, the higher the price it will bring.

No detail in the marketing of hay has more to do with the final profit than the matter of grading. If a customer wants a fancy grade of hay, he must be willing to pay a fancy price, while if he is willing to accept a grade which is less fancy but which is just as good for feeding purposes, he usually will be able to purchase his supply at a much lower price.

The National Hay Association standard grades for different hays are now generally used in all leading hay markets. These grades for Bermuda hay are as follows:

No. 1. Bermuda hay shall be Bermuda grass mixed with not more than 10 per cent of native grasses, color of uniform greenish cast, sound, tender, and well baled.

No. 2. Bermuda hay shall be Bermuda grass mixed with not more than one-fourth native grasses, color of greenish cast, with not more than 15 per cent brownish blades, sound, tender, and well baled.

No. 3. Bermuda hay shall be Bermuda grass mixed with not more than one-fourth native grass, color of brownish cast, sound, and well baled.

While there are no great differences in the actual feeding values of the three grades, there is a considerable difference in their market selling prices, and the grower should govern his practice accordingly.

Hay which has a bright-green color is always in demand, as it has been well cured. As a matter of fact, as has been shown by many tests in this country and in Europe, hay which has become somewhat browned in curing but which is not moldy or musty is just as valuable for feeding as that which is green in color, but it does not sell as well on the market. In the United States green hay commands a much higher price. The grower should always try to make green hay when he proposes to sell the product, while the browned hay can be saved for use on the farm. Horses and mules will eat the latter hay as readily as the former. The greatest value in the green color is as a guaranty that the hay is well cured and free from dust and mold.

The next most important specification is in regard to baling. All grades must be well baled, as no customer wants bales with one or two loose wires.

FEEDING VALUE.

Little accurate work has been done at any of the agricultural experiment stations in making either feeding or digestion tests with Bermuda hay, though the general experience of feeders in all parts of the South has shown that it is fully as valuable as any other grass hay.

Bulletin No. 15 of the Mississippi Agricultural Experiment Station reports that six lots of cows, five cows in each lot, were fed for testing different rations for the production of milk and butter. One of these lots was fed with Bermuda grass and another with timothy hay, both lots receiving the same grain ration. The financial results of the test were based on Bermuda hay at $12.50 a ton and timothy at $20.80, the actual cost at the time. On that basis the cost of the milk from the Bermuda-fed lot was 7.7 cents a gallon and of the butter 17.4 cents a pound, while the milk from the timothy-fed lot cost 12.8 cents a gallon and the butter 29.5 cents a pound. The bulletin says: "Had the timothy cost no more than the Bermuda hay the cost would have been 9.5 cents a gallon for the milk and 21.9 cents for the butter." This leaves a margin of about 25 per cent in favor of the Bermuda hay.

This work was continued the following year and the results, as given in Bulletin No. 21, were slightly less favorable to Bermuda-grass hay but indicated that "ton for ton the two hays have practically the same milk and butter producing values" and "at the prices at which they can be purchased in Mississippi, Bermuda hay will produce milk or butter at a much less cost than will timothy."

Bulletin No. 15 of the Mississippi Agricultural Experiment Station, in reporting on the values of different hays for mules, says:

> In order to ascertain the comparative values of Bermuda and timothy hays for feeding to working animals, the six working mules belonging to the station were divided into two lots, one mule from each double team being placed in each lot. Both lots received the same amount of corn daily and were given all the hay they could eat, the feeding being continued two months. The results showed that there was practically no difference between the two rations, the food for the lot fed with timothy costing 36 cents more for the entire period than that for the Bermuda-fed lot, the lot receiving timothy gaining 92 pounds during the two months, while the other lot gained 90 pounds.

Prof. E. R. Lloyd, director of the Mississippi Agricultural Experiment Station, in a recent letter published in the Progressive Farmer, states that another test was made in 1915 with five lots of mules, each lot containing four or five 2 and 3 year old mules, the test being continued 89 days. Each lot received the same amount of grain per mule but were fed with different hays. Bermuda grass, Johnson grass, timothy, lespedeza, and alfalfa hays were used and the cost of each was figured at the local market price then prevailing. The cost of feed for each lot for the 89 days was as follows:

Bermuda grass	$14.36
Johnson grass	14.36
Lespedeza	16.38
Alfalfa	16.38
Timothy	18.90

The feeding value of any hay is indicated to some extent by a chemical analysis showing the proportions of its several nutritive components, and of these components the protein is by far the most important. These components in Bermuda grass, timothy, and Kentucky bluegrass, as given by the Bureau of Chemistry of the Department of Agriculture, are shown in Table I. The calculations were made on a water-free basis.

Table I.—*Chemical analyses of Bermuda grass, timothy, and Kentucky bluegrass.*

Crop.	Number of samples.	Protein.	Fiber.	Starch, etc.	Fat.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Bermuda grass	19	10.50	27.48	51.18	2.54
Timothy	104	8.19	32.53	49.87	3.18
Kentucky bluegrass	84	11.89	29.48	47.37	3.57

From the above it will be seen that Bermuda grass contains 2.31 per cent more protein than timothy and 1.39 per cent less than bluegrass, as well as more starch and less fiber than either.

In American literature only a single digestion test with Bermuda hay is recorded, so there is need for further work along this line to determine its feeding value more definitely. A comparison of the digestibility of Bermuda hay, as shown by Bulletin No. 90 of the Oklahoma Agricultural Experiment Station, giving the results of tests with sheep, and the digestibility of timothy and bluegrass, as shown by various publications of the Department of Agriculture and several of the agricultural experiment stations, is given in Table II.

Table II.—*Comparative digestibility of Bermuda grass, timothy, and Kentucky bluegrass.*

Crop.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Bermuda grass [1]	64.2	58.9	52.7	39.6
Timothy	48	50	62	50
Kentucky bluegrass	57	66	61	52

[1] The analysis of the hay used in the work of the Oklahoma Agricultural Experiment Station was as follows (per cent): Water, 7.87; ash, 7.44; protein, 10.81; fiber, 28.87; nitrogen-free extract, starch, etc., 43.58; fat, 1.42.

While these figures indicate the possible feeding value of Bermuda grass, its actual value can be determined only by repeated feeding tests with different animals. In making such tests the feeder must take into consideration the soil on which the grass was grown, the character of the season, and the age at which the grass was cut, as each of these conditions will influence both the composition and the digestibility of the hay.

Timothy was one of the first hay grasses to be grown in this country and by its wide cultivation and extensive use has become the standard by which other grass hays are judged. For this reason many buyers suppose timothy to be the best in quality. Southern feeders, however, are beginning to recognize the value of Bermuda grass. In all the regions where this grass can be grown well a dollar's worth of it will furnish more feed than a dollar's worth of timothy. It is therefore the cheaper hay for use in the South.

Furthermore, at present prices, on the farms where grown, Bermuda grass is more profitable to the southern farmer than timothy is to the northern grower.

ERADICATION.

Many farmers hesitate to plant Bermuda grass for fear it can not be killed out when the land is wanted for other purposes. It may be thoroughly eradicated, however, when advantage is taken of its peculiarities. It is almost impossible to kill Bermuda grass by cultivation in the summer or by deep plowing at any season. In the northern part of the Bermuda-grass region it can be almost or wholly eradicated by a very shallow plowing late in the fall, leaving the furrows on edge as much as possible, so that the "roots" will be frozen during the winter. Few of the "roots" will survive a single heavy freeze when turned up and exposed to the air. Farther south, where frosts are less severe the grass must be killed by smothering. Bermuda grass will bear almost unlimited heat, drought, and sunshine, but it can not live when shaded. When it is desirable to clear a field it should be plowed in September and planted with oats, rye, barley, or some other winter crop. When that crop is harvested the ground should be disked or plowed at once and then planted with cowpeas or velvet beans. When the pea or bean crop is removed, there will be little or no Bermuda grass left. This gives two profitable crops during the year and leaves the ground in prime condition for corn or cotton the following season.

Another method, which is often followed, is to plow the sod very shallow in the fall, harrow thoroughly, and then rake the "roots" into windrows and haul them off. If this process is repeated in the spring little of the grass will be left. A bulletin of the South Carolina Agricultural Experiment Station says that the grass may be killed by disking, cross disking, and harrowing a few times during the winter.

In California and other arid regions it can be killed by withholding irrigation a few months. Varieties like the Giant and the St. Lucie, which have no underground rootstocks, can be almost wholly killed by allowing the late fall growth to stand and then burning it off after it has become dry. It is much more easily killed on light than on heavy soils.

SUMMARY.

Bermuda grass is the most valuable perennial grass in the southeastern part of the United States and is common in all the warmer parts of the world. It has been grown in the United States for more than a hundred years.

It requires a warm climate for its best growth; it does not bear heavy freezing or dense shading, but endures drought better than most other grasses. It grows best on a soil which is fertile, fairly moist, well drained, and rich in humus and nitrogen.

There are several distinct varieties, differing principally in vigor of growth and in the character of the rootstocks and runners. Of the many forms which have been tested by the United States Department of Agriculture the Giant grows most rankly and so is the best for hay.

The yield of hay varies greatly with the locality in which it is grown. In many localities Bermuda grass does not grow large enough to pay for cutting, while on very favorable soils it may yield annually 6 to 8 tons of hay per acre.

It is the best permanent pasture grass in most of the South. On soils of ordinary fertility it will support about 1 steer per acre for eight to nine months, while on exceptionally favorable soils it may support four or five steers for a longer time. Pastures may be greatly improved by growing some legume with the Bermuda grass—lespedeza, bur clover, black medic, and melilotus being the species commonly used for the purpose.

Bermuda grass is of great value for use in stopping the washing of gullies and in binding levees and other embankments.

Its feeding value is fully equal to that of timothy, though its market value is usually less.

It can be eradicated either by freezing the "roots" or by keeping the ground heavily shaded by the growing of other crops.

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ORGANIZATION, FINANCING, AND ADMINISTRATION OF DRAINAGE DISTRICTS

H. S. YOHE

Expert on Drainage Organization

FARMERS' BULLETIN 815

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Public Roads and
Rural Engineering

LOGAN WALLER PAGE, Director

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THE ORGANIZATION, FINANCING, AND ADMINISTRATION OF DRAINAGE DISTRICTS.

CONTENTS.

	Page.		Page.
Introduction	3	Levy of drainage tax	18
Development of drainage organizations	4	Financing of drainage districts	19
Factors to be considered before organizing a drainage district	5	Payment of bonds and interest	26
Procedure to effect a drainage organization	7	Records of drainage districts	29
Engineering features	11	Administration of drainage districts	32
Determination and confirmation of benefits	13	Necessity for adequate maintenance	35
		Summary	36

INTRODUCTION.

In the early development of the country, when more land was available for cultivation than there were farmers to till it, it was quite natural that those looking for farm lands should pass by the wet lands. Nevertheless, there were tracts of land on many farms which, because of their wet condition, were used for nothing but pasture and that only during dry seasons. In addition to these wet lands on the individual farms, there were large areas of flat lands forming swamps which were wet throughout the year, while others lying along creeks and rivers were affected so frequently by the overflow from these streams that they never were cultivated.

As population increased, tillable land became scarcer and higher in price, so that farmers who wished to extend their holdings, and others who desired to engage in agriculture, began to consider seriously whether it would not be cheaper to drain the neglected wet lands than to buy lands which required no drainage. The favorable results obtained from scattering individual efforts in reclaiming these lands led to the undertaking of drainage on a large scale. As the demand for agricultural lands continues, the drainage of wet and overflowed lands in the various parts of the country will be undertaken as rapidly as is practicable economically. To give persons interested in this kind of reclamation some idea of the type of organization which has been found best suited for accomplishing this work is the purpose of this report.

NOTE.—This bulletin is prepared to aid landowners, district officials, and others interested in forming drainage districts for the purpose of reclaiming swamp and overflowed lands. It presents methods of organizing the interested property owners and principles which should be considered in the administration and financing of drainage districts. It is particularly applicable to drainage districts in the humid regions of the United States. Because the laws in no two States are exactly alike, the subject necessarily must be treated in a general way.

DEVELOPMENT OF DRAINAGE ORGANIZATIONS.

INDIVIDUAL EFFORT.

The first attempts at drainage were made by a few individual landowners who were convinced that their wet lands would be highly productive if drained. Usually their first efforts were confined to draining wet places in their cultivated fields. Later, those who tilled land adjoining large areas of wet land extended their cultivable area by draining a few acres of this wet land. This individual effort, however, usually was costly and frequently did not produce satisfactory results. Again, it did not permit drainage of more than a comparatively few acres, for the farmer usually could not get the required outlet on his own farm to drain a large tract.

VOLUNTARY COOPERATION.

These individual attempts at drainage were followed in progressive communities by united effort made in the hope of getting more effective drainage and adequate outlets at lower costs. Several farmers who could use a common outlet, or who by natural conditions were obliged to use a common drain to reach an outlet, undertook to cooperate in constructing drains. Their attempts to agree upon the location of drains, methods of construction, and distribution of costs generally ended in a quarrel and only occasionally was it possible to complete the proposed improvements. Such united effort, while in some instances an improvement over that of the individual farmer, was not suited to carrying on drainage on a large scale. The landowners lacked responsible, continuous organization; as a unit they had no standing in the eyes of the law; they could not borrow money except as each member made himself personally responsible; they had no responsible executive head; they possessed no machinery for determining and enforcing the collection of each landowner's share of the cost; they were strong or weak, and succeded in accomplishing or failed to accomplish their purposes in proportion only as the individuals had the capacity and disposition to work in harmony and adjust differences. These so-called organizations were not fitted to carry on work on even a small scale efficiently and at a minimum cost. When projects involving thousands of acres were to be undertaken, it developed soon that adequate outlets could not be obtained except by carrying the ditches across the lands of uninterested parties. As the landowners were not serving a public purpose, they could not cross the lands of uninterested persons unless some agreement could be made with the owners, which frequently was impossible. Further, the systems so constructed frequently would afford drainage to the lands of owners who would not join with their neighbors, and who could not be compelled to pay for the benefits thus conferred upon their lands. In addition, then, to the inherent weaknesses, this cooperative effort was wholly inadequate in that it did not possess any power whereby all landowners who were benefited could be compelled to pay their just share of the costs, nor did it possess the machinery for forcing any landowner to permit the construction of drains across his lands when necessary to secure outlets. In short, the landowners who wished to drain could suggest and negotiate, but they could not compel action even among themselves.

DRAINAGE DISTRICT ORGANIZATIONS.

The failure of individual and voluntary cooperative efforts to accomplish drainage economically indicated the need for a responsible, continuous organization clothed by the legislature with certain powers. To meet this need practically all the States in which are located large areas of wet lands have enacted laws providing, under certain conditions, for the organization of lands into a drainage district. When properly organized these drainage districts possess the following distinguishing attributes:

1. By law they are made a form of corporation and act through boards of officers.
2. They can borrow money and issue bonds in the name of the district.
3. They are financially responsible, and may sue and be sued in the district name.
4. They possess the machinery for making an equitable distribution of costs in proportion to benefits conferred.
5. They are authorized to levy taxes against each piece of land to the extent of benefits conferred, and to use the State machinery for collecting such taxes.
6. They have the power of eminent domain, which gives them the right to condemn property needed for carrying out the purposes of the district.
7. They possess the power to construct such improvements as are necessary to accomplish the reclamation of the lands in the district.
8. They may hold and convey property.

SOME FACTORS TO BE CONSIDERED BEFORE ORGANIZING A DRAINAGE DISTRICT.

SELECTION OF PROJECTS.

It should not be inferred, because laws have been enacted to provide the machinery for reclaiming swamp and overflowed lands, that the drainage of all such tracts necessarily will meet with assured financial success. With present land values, not every project feasible from an engineering standpoint is practicable economically; for it might be possible to buy other lands, equally fertile and not requiring drainage, at less than it would cost to drain swamp or other wet lands. Each project must be considered solely on its own merits and as a business proposition. In other words, the question to be decided is, will the improvement prove a profitable investment?

Again, while the laws make it impossible for a few nonprogressive or obstinate landowners to prevent such improvements, the drainage of land for agricultural purposes should not be undertaken unless there is a sound demand for more agricultural land in the community, or unless settlers can be assured for the projects immediately following the completion of the improvements. Every sound project must have its origin in economic need.

Neither should a project be undertaken unless the sentiment of a good majority of the landowners is favorable to the project, for its final success depends upon their approval and support. If the project is to be constructed at a reasonable cost, every effort should be made on the part of those interested to secure the cooperation and good will of the landowners who will be affected, for a landowner opposed to the project can cause an endless amount of trouble, delay, and expense. In communities where the results obtained from drainage are not generally known a proper presentation of what it is proposed to do and of the expected benefits frequently will overcome opposition.

EMPLOYMENT OF COMPETENT ATTORNEY.

It must be remembered by the promoters that a drainage district is a creature of the law; it comes into existence by and derives its powers from the law, and hence the necessity for a strict compliance with the law. This suggests the employment from the beginning of an attorney who will take a personal interest in the district and who not only will familiarize himself with every detail of the drainage law and observe its requirements strictly, but who will study the decisions by the courts on drainage laws. Many costly errors might be avoided if the attorneys of drainage districts would make it their business to study the experiences of other districts in the light of court decisions. Generally an attorney who has had experience with the organization of drainage districts is to be preferred to one who has had no such experience. If an attorney is not familiar with the organization of drainage districts he should not agree to serve unless he is willing first to make a thorough study of the subject. There are no short cuts in the organization of drainage districts; if the law states that certain things shall be done in certain ways, no course short of compliance with the law will suffice. Carelessness as to the contents of papers, or failure to file them at the proper time with the proper officials, has caused districts no end of litigation and expense, and in some cases has resulted even in the districts being unable to sell their bonds. From the filing of the first paper the attorney for the district should remember that his work in a large measure will affect the salability of the district's bonds.

As no drainage district comes into being until after the filing of the petition and its approval by the court, the selection of an attorney to initiate proceedings rests with the petitioners. Before they engage an attorney, a definite written agreement should be had covering the question of fees he shall receive for any services he may render. It follows that upon the organization of a district it becomes the duty of the officers to retain an attorney by contract.

PROCEDURE TO EFFECT A DRAINAGE ORGANIZATION.

THE PETITION.

Number of petitioners.—The first step in promoting a drainage district is to prepare a petition signed by the required number of landowners for presentation to the proper official, as designated by the law.

The laws of the States differ as to the number of signers to the petition. In some States it must be signed by a majority of the landowners living in the district; in others by the owners of a majority of acres; in one State a petition may be presented by but three landowners and in several by only one. Many laws have two provisions as to the number of signers to the petition, a compliance with either one being all that is necessary. After a petition has been signed and presented to the court or other proper official, it has been held in several instances that a landowner has no right to withdraw his name.

Requisites of the petition.—As to the subject matter of the petition, most laws require that it shall represent that certain lands are subject to overflow or are too wet for cultivation, and set forth in general terms the boundary lines of the lands so affected which it is proposed to include in the district, the names and addresses of the owners of land within the district, together with a description of the lands owned by each, and the approximate starting points, routes, and termini of the proposed improvements. Usually a statement is required also to the effect that the drainage of the lands in question will promote the public health, convenience, benefit, and welfare.

Too much care can not be taken in the preparation of the petition. Unless it contains all the facts the law requires to be set forth, and unless it is signed by the requisite number of landowners, then it is no petition. If the court or officials should overlook the failure of the petition to fulfill all requirements, and should act on such a petition, approving the formation of the district, and if under such a defective petition, a district should proceed to make costly surveys and incur other indebtedness, and then, when it is attempted to assess the landowners for their shares of these costs, a landowner should object on the ground that as the petition did not comply with the law no district ever had been created, the courts would be obliged to decide against the district. The necessity for caution in the preparation of the petition therefore becomes apparent; and yet, recently in a State where the law specifically requires that the petition set forth four facts, only two were indicated in the petition. It was assumed that a district existed, surveys and plans were made, but some of the landowners opposed to the undertaking raised the question that the petition was not sufficient in law, or, in other words, that the district had not been organized legally. The success of their contention would mean the filing of a new petition and repetition of the whole procedure. Such action always is costly and tends to create a feeling of indifference among those desiring drainage, sometimes even causing them to join with the opposition. The question that comes naturally to mind is: Why did not the petition set forth the four facts mentioned in the law? The only answer that can be made is that the attorneys who prepared the petition followed an incorrect form instead of familiarizing themselves with the drainage law of the State and following it. In the formation of a drainage district no form should be followed unless it has been checked carefully by the attorney of the district to see that it meets the requirements of the law.

A description of the location and boundaries of the proposed district is included so the officer to whom the petition is presented may pass intelligently upon the desirability of establishing a drainage district and decide whether drainage would prove beneficial. Generally each particular tract to be included in the district need not be described with specific detail, but statutes requiring the names of the owners and the acreage and description of holdings must be complied with strictly. The erroneous inclusion of lands within the boundary of the district generally will not make the petition defective; neither will the omission of lands concerning which there is some doubt as to whether they should be included, for they can be brought in at any time before assessments are confirmed. Lands already in one drainage district may be included in another if they will derive any benefit from the subsequently formed district.

The starting points, routes, and termini of the proposed improvement need be described only approximately. A description given as "somewhere near" a certain section has been held sufficient. Naturally at this stage of the proceedings it would be impracticable to describe accurately the locations, starting points, and courses of the improvements. The laws have provided for detailed surveys to ascertain these.

The petition should close with a request that the court appoint a competent engineer to make a preliminary survey to ascertain the lands which will be benefited by the proposed system of drainage, and whether, in his opinion, drainage of the lands is practicable and desirable. Under the drainage law of at least one State no engineer is appointed at this stage of the proceedings, but a hearing is had on the petition.

Bond for organization expenses.—In most instances the petition must be accompanied by a bond in amount sufficient to pay for preliminary surveys and organization expenses in case the district is not formed, or in such other amount as the court may require. In one State the petitioners may accompany the petition with articles of association, obligating themselves personally to pay such expenses in proportion to their respective acreage in case the district is not formed; and in at least two other States the officers of the district are authorized to levy a uniform tax, not to exceed 50 cents per acre on each acre of land in the proposed district, to be used in paying preliminary and organization expenses.

Filing of petition.—In many States the petition is filed with the county court; in others with the clerk of the county or district court; and in still others with the county auditor or board of county supervisors. For convenience of discussion it will be assumed here that original proceedings are had before the county court.

Those interested in forming the district should realize the importance of filing the petition with the officer designated by the law under which it is desired to form the district; yet in States having more than one law petitions have been filed with an officer designated by a law under which it was not the desire or intention of the landowners to operate. Subsequent proceedings were had under the law originally intended; but, as it of course developed, these proceedings were void because the officer had no jurisdiction for the simple reason that the petition was not filed with him.

THE PRELIMINARY REPORT.

In compliance with the request made in the petition, the court appoints a competent engineer or a board of viewers composed of an engineer and two disinterested freeholders to make a preliminary survey. Under laws providing for a board of viewers, this board serves to make the plans and assess the benefits. Within a specified time the engineer must submit to the court his report giving a general idea of the location, character, and cost of the proposed improvements and indicating the lands that will be benefited. The report should contain also such other general suggestions as seem proper. This report, it should be remembered, is merely advisory to the court, to aid it in deciding as to the establishment of a district, and is not conclusive as to the actual cost of the improvements, their exact location and description, or of the amount which it will be necessary to assess against the lands in the district.

NOTICE OF FILING OF PETITION AND REPORT.

Upon the filing of the engineer's report, all persons holding property within the proposed district should be notified of the petition and report pending in court, and called upon to appear before the court at a certain time and place to show cause in favor of or against the establishment of the proposed district. In many States this notice is served on the landowners personally; in others, by publication only. Usually, nonresident landowners are served with notices by publication only.

Some statutes prescribe a particular form of notice and in such cases the form must be followed, but in most laws no such form is given. Whatever form this notice may take, it should be remembered its purpose is to secure to the owners the opportunity to protect their property from an unjust lien or tax; therefore, it should be so full and clear as to disclose in a general way to persons of ordinary intelligence the effect the granting of the request of the petitioners would have on the lands to be included in the proposed district. When notice is given by publication, the publication must be made through such a medium and in such terms that the owners of the property will be reasonably certain to receive information as to what it is proposed to do, either by their own personal reading of the publication or through those in charge of their properties. It must inform them also as to when and where they may be heard. Should the law not specify the place and date for hearing, care must be taken that both the place and date determined upon are such that with reasonable effort those who will be affected will be able to attend in case they wish to offer objections. Usually the law specifies the shortest time within which a hearing shall be had. When the statutes provide a definite method for serving notice this must be followed strictly. Most statutes require that the published notice shall designate the boundaries of the district as well as the holdings of the owners, so that all property owners may ascertain easily whether their property is included.

HEARING ON PETITION.

On the day set for the hearing the court gives every landowner an opportunity to present his views as to the advisability of establishing a district. If the petition is dismissed costs are apportioned against the landowners. Under the laws of some States landowners who think they will be damaged by the improvements may file claims for damages a certain number of days prior to the date set for the hearing.

Following an order of the court directing the establishment of the district, the land involved becomes segregated for the purpose of drainage from other lands, and is known thereafter by the name conferred upon the district by the court. The distinguishing features of the district henceforth are, that as long as any act remains to be done the district is presumed to be in existence, with a board of officers through which such action can be and should be taken; that it can borrow money in the name of the district; that by the power of eminent domain it can acquire by condemnation or purchase such lands as are necessary for carrying into effect its purposes; and that it has the power to raise money for meeting its obligations by levying taxes on the lands that will be benefited by the proposed improvements.

GOVERNING BOARD OF DRAINAGE DISTRICT.

Each district has its own board of officers, usually called commissioners or supervisors. However, in a few States this board is not appointed until after the final hearing on assessments. For convenience, the drainage board will be referred to as "commissioners."

The commissioners generally are elected by the landowners from their own number, though frequently the first board of commissioners is appointed by the court, acting on the advice or recommendations of the landowners. In some States certain county officials are designated by law to serve as the officers of drainage districts in their respective counties.

In States where the commissioners are selected from among the interested landowners, the laws require that as commissioners they shall take a prescribed oath within a specified time after election. These oaths should be filed in the records of the district. If the oath is not so taken the person appointed or elected is, under some laws, regarded as having declined to serve as a commissioner, and the court is authorized to appoint another person. The act of any one serving as a commissioner without having taken the required oath is void. Therefore it is essential that all preliminary acts which the law requires of commissioners to qualify them as such should be performed before they undertake to act.

ENGINEERING FEATURES.

SELECTION OF COMPETENT ENGINEER.

The commissioners of the district employ an engineer to prepare a plan of drainage for the district. Before selecting this engineer they should make thorough investigation as to his competency and feel reasonably satisfied that he has had sufficiently wide experience to enable him to design and construct the improvements properly. Too frequently an engineer who has little knoweldge of the theory of drainage practice, and who has had even less experience, is selected in preference to a man of wide experience and training, simply because the former can be secured for a little less money. So-called "cheap" engineering service usually proves the most expensive. Only the competent engineer is qualified to decide which of several plans will be most efficient and most economical. A contract between the district and the engineer should cover the various matters upon which they have agreed and the compensation which is to be paid.

"CHEAP" DRAINAGE NOT ECONOMICAL.

There is another phase to the engineering side of drainage districts which the commissioners must consider. Inadequate drainage improvements are not always to be laid at the door of the engineer. Landowners often demand "cheap" drainage; they will pay a certain amount but no more. There are a number of improvements which the landowners contend are inadequate and from which they assert they derive no benefits. In many such instances investigation will reveal that the engineer had prepared plans that would have afforded ample relief, but because the landowners declined to spend what such a system would have cost, the ditches were reduced in size materially. The commissioners should impress upon the landowners that it is economy in the end to construct improvements of ample capacity and that the engineer, and not the landowner, is the better qualified to determine the needs of the district and the adequacy of proposed improvements. The engineer should be instructed to prepare his plans regardless of any information which may come to him as to the amount the landowners may be willing to put into construction, and to design the most feasible and economical plan and let the cost take care of itself.

Usually, when the landowners fail to get the relief they expected, they determine to have better drainage and to improve the existing system. This means starting over the whole proceeding, and involves additional expense. An example of the waste of money resulting from such procedure is in a district costing about $450,000, of which one of the drainage commissioners recently remarked that the "piecemeal" method pursued cost the landowners at least $100,000 more than if they had followed the plan originally designed which the commissioners wanted and the landowners rejected.

It frequently is difficult to raise money to complete a drainage project the cost of which was underestimated originally, or for the purpose of reconstructing an improvement which originally was represented to be adequate but proved inadequate. The idea of "cheap" drainage should be supplanted by the idea of "adequate, economical" drainage. An eminent consulting engineer recently remarked that in connection with drainage improvements the "expenses and final costs are too frequently underestimated, with the result that sufficient money is not available to complete an adequate system." It always is better to overestimate than to underestimate the cost.

APPROVAL OF PLANS BY CONSULTING ENGINEER.

It would be real economy, at least on large projects, for the commissioners to employ a consulting engineer to pass upon the engineer's report, plans, and specifications after he submits them to the commissioners for examination and approval, and before they are filed in court. Some of the landowners may object to the expenditure, but approval by a consulting engineer gives the bonds of the district a much wider market, and at the same time the additional price the bonds will command usually will be considerably in excess of the fee of the engineer.

COMPETENT ENGINEER TO SUPERVISE CONSTRUCTION.

A competent engineer should be employed to supervise the construction of the improvements. He should have full charge of the work and be the agent through whom the commissioners deal with the contractor in matters affecting it. His decision as to whether the work done complies with the specifications should be final and be upheld by the board of commissioners. No accounts should be paid or work accepted without the engineer's approval. The commissioners, who usually do not possess sufficient technical knowledge to enable them to decide intelligently whether the improvements comply with the plans and specifications, must rely upon the engineer for advice before accepting or rejecting any completed work.

The high cost of employing a cheap engineer during the construction period is shown in the case of a district in which the improvements cost approximately $85,000. A local engineer with no experience in drainage work was employed to supervise the construction. He made the required inspection and reported that the work complied with the plans and specifications. Acting upon his report, the commissioners paid the contractor in full. Later it developed that the drainage ditches were not giving the relief they should, and another engineer was employed to inspect the construction. It was found that several miles of the main ditch had not been dug according to specifications. Reconstruction cost the district $7,000. Later, in commenting on this item of expense, one of the commissioners said that the district would have saved about $3,000 if it had secured an experienced drainage engineer originally and paid him twice as much as was paid the engineer employed.

DETERMINATION AND CONFIRMATION OF BENEFITS.

BOARD OF ASSESSORS.

In some States, when the engineer's report is filed, a petition is filed by the commissioners asking that the court appoint a board of assessors to determine and assess the benefits which each tract of land will receive from the proposed improvements; in other States two disinterested persons are appointed to serve with the engineer in making this assessment. However, in many States this appraisal or assessment of benefits is made by the commissioners.

NECESSITY OF ADEQUATE RECORDS.

It should be remembered that the benefits assessed form the basis for taxing each landowner for his share of the costs, and that unless these assessments are valid the taxes can not be enforced. Drainage taxes generally are questioned by the property owner, and it is in connection with the assessments that most of the litigation occurs. This suggests the necessity for the assessing board to keep carefully adequate records which will show upon what basis the assessment was made against each tract. If, by the records, it can be shown to the court that the benefits were determined by just principles, it is not likely that the findings of the board will be disturbed. However, such a showing can not be made if, as is sometimes the case, the notes of the board are made on scraps of paper, envelopes, and small pocket notebooks. Before taking up the field work of assessments, the law should be consulted and forms prepared to comply with it, so that the field work may proceed rapidly and systematically. All field data thus collected should be carefully and systematically preserved.

IMPORTANT POINTS IN MAKING ASSESSMENTS.

All benefited property assessable.—In making the assessments many State laws require that each 40-acre tract, or other subdivision of land according to ownership, shall be considered; also, that consideration be given to the benefits conferred upon highways, railroads, rights of way, and other property. If the board of assessors feels that certain lands not included within the boundaries of the district will be benefited by the proposed improvements, these lands also should be assessed. Notice similar to that served on the landowners of the filing of the petition and preliminary report of the engineer should be sent to the owners of lands so included, and a similar hearing granted. At the same time that benefits are being assessed, a record should be made of all damages to property by reason of the construction of the drainage system. Properly signed releases should be obtained from those who agree not to file any claims for damages.

In making the assessment of benefits the assessors must remember always that their duty is to determine the total amount of benefit that will accrue to each tract. Usually the only limitation found in the statutes and constitutions upon the amount that may be raised by special assessment against property in a drainage district is that the amount shall not exceed the benefits. These benefits may be several times greater than the cost of the improvements, or they may be less, though the latter condition seldom exists. The point is to consider benefits only and to assess the full amount. Mention of this is made because in at least one district, instead of assessing benefits the board assessed costs, and if the error had not been corrected the district would not have had enough funds to complete the work, as the cost was underestimated. This would have made it necessary to go over the whole proceeding. It always is advisable to assess the full amount of benefits, even if such amount be much in excess of the cost of the improvements. By so doing, in case more money be needed, it will not be necessary, under many laws, to go into court again, as taxes equal to the benefits approved by the court may be levied by the drainage commissioners.

Assessments must be based on benefits.—No attempt will be made in this bulletin to discuss in detail the various factors to be taken into consideration in making assessments. The settled rule is that in making special assessments for drainage improvements the amount of the assessment must be based on the special benefit which it is estimated will be conferred by the improvements. This benefit must relate to the betterment of the land for a purpose to which it may reasonably be put. Lands which before drainage were useless might, after drainage, be suitable for manufacturing, but as it may be quite evident that they will be used for agriculture, they should be assessed on the basis of benefit conferred upon them for agricultural, and not manufacturing, purposes. The situation of lands with respect to natural drainage is a controlling factor in their value. It has been held that as the purchaser of naturally well-drained land pays for a favorable situation in the first place, he can not be compelled to contribute to a drainage project organized to drain adjacent lowlands unless he derives some special benefit from the work. The assessors should feel reasonably certain that they can show a special benefit to such lands before placing an assessment against them. If the only benefit conferred upon land is an advantage such as is general to the public, no assessment can be made.

Educational work necessary.—Unless the assessment of benefits is made with a view to doing justice to all, serious objection is sure to follow. Those charged with making assessments usually are conscientious in the performance of their work, though of course they may assess some land erroneously, and to such assessments it is proper to object. However, many objections are due to the fact that landowners are not acquainted with the benefits that result from drainage. They must be educated, and here is the opportunity for the commissioners to show superior ability. Landowners naturally want to feel that their interests are being guarded. By acting openly and pointing out the benefits received from drainage in other sections, the commissioners will gain the confidence of the landowners, and few objections will be raised to the assessments. If the commissioners can refer the property owners to districts in which untilled land or swamp land has been increased by drainage to $50 or $100 per acre in value, and has been made to yield good crops every year, naturally the property owners will become interested. Reference to cases similar to the following would serve for this purpose:

In a district, which cost about $40 per acre, it was desired to make another assessment for installing additional pumping equipment and cleaning out existing ditches. The assessment against a certain tract would have been $12 per acre, and the owner objected. When a member of the board pointed out to him that the value of his crop, per acre, the year before the assessment was made was almost five times the assessment, and that by the installation of the additional pumping equipment he would be insured of a crop every year, the objection was withdrawn at once. In another State, lands which were worthless swamps have been transformed by drainage into some of the best sugar-beet lands in the State, and now are worth $150 per acre. In another district land which was overflowed every year during high water and which never could be used for anything except pasture, was converted by drainage into high-yielding corn land and now can not be bought for $150 an acre. Again, from lands which a few years ago were nothing but swamps the landowners, as a result of drainage, are taking 75 to 95 bushels of corn and cotton worth $75 to $125 per acre. Any number of such cases can be found, and if serious opposition is developing the commissioners can do nothing better than to ascertain the results obtained in sections where drainage has been practiced for some time. Frequently there are near-by districts possessing the same soil and the same drainage conditions as the proposed district. These will serve as excellent examples. Of course, an obstinate landowner can be forced, but it always is better for the district if the landowner can be persuaded to cooperate.

Preparation of assessment roll.—After all the necessary field examinations have been made by the commissioners, they compile an assessment roll. This should give the name of the owner of each piece of property assessed, a description of the property, the number of acres, the amount of benefits shown in dollars and cents assessed against each tract, the amount of property taken for right of way and its value, and any damages which may be sustained by reason of the construction of the improvements. Even if the law requires a classification of benefits only on a percentage or some other basis, it always is advisable to indicate the benefits to each tract in dollars and cents.

Notice of assessments to landowners.—Upon completion of the assessment roll it is filed with the court, and notice is given to all persons affected. This notice should contain a description of the lands assessed, the amount of benefits so assessed, expressed in dollars and cents, and should inform the owner of the lands when and where he may appear to object to the assessment made against his lands, if he so desires. If notice is given by publication only, the name of the owner of each tract should appear opposite the tract described. At this hearing, if any landowner considers he has not been awarded proper damages he may be heard on this subject also.

The necessity for care in the preparation and serving of notice at this time can not be emphasized too strongly, for upon the assessment roll, as finally approved by the court at the time of this hearing, rests the enforceability of the taxes. The descriptions given in the notice should be checked carefully against those contained in the engineer's report. In notice by publication only it has happened that the descriptions given did not correspond with those in the engineer's report and plans, and as a result the lands were held not to be in the district. Subsequent taxes levied against these lands were not collectible. An eminent attorney who has approved many drainage bonds has said that fully 75 per cent of the drainage district records he has refused to approve are faulty or defective in descriptions given in the notices at this stage of the proceedings. A defective record means that bonds can not be sold. Of course, the commissioners do not prepare these notices, but it is their duty to impress upon their attorney the need for care in their preparation.

Approval of assessment roll.—At the hearing the court, after making such changes in the assessment roll as it deems necessary to do justice to all, enters an order on its records approving the roll. After such approval the commissioners have no power to make any change without first giving notice to all the landowners. If it should develop that benefits assessed are less than the estimated costs, the district must fail, for the only way under the law to raise money to pay for the improvements is by taxing each parcel of land, and these taxes must be based on benefits conferred. Further, they must be spread in such a way that no land will be burdened more than its proportionate share of the cost of the improvements. If the system costs more than the total benefit which the land would derive, it is obvious that sufficient money could not be raised to meet this cost. From the findings of the court, as to both benefits and damages, each landowner has a right to appeal to a higher court within a certain time, but unless the appeal is taken within that time he is considered by the law as satisfied with the assessment made against his land and the damages awarded. A copy of the assessment roll, showing the lands affected by the assessment, should be filed with the county recorder, so that the lien may be recorded. This copy should be prepared by the secretary of the district.

LEVY OF DRAINAGE TAX.

After the assessments of benefits are approved the court, at the request of the drainage commissioners, makes an order levying against the property in the district a tax equal to the estimated cost of the improvement, with 10 per cent added for contingencies. The amount of the tax levied against each tract must be in proportion to the benefits which the assessment roll shows will be conferred upon the tract. Whether the law requires it or not, it always is advisable to levy taxes 10 per cent in excess of the estimated cost, for usually some small additional costs arise as the work progresses.

RIGHT TO PAY TAXES IN ONE AMOUNT.

After the tax levy has been made the landowners are accorded a certain time within which they may pay the taxes in one amount. The commissioners should make every reasonable effort to inform the landowners of this privilege, for unpaid drainage taxes usually draw 6 per cent interest. Frequently many landowners could and would pay their taxes within the prescribed time if they understood that unpaid taxes draw interest. In Iowa, Illinois, and Minnesota it is not uncommon to find as many as 50 to 60 per cent of the landowners paying their drainage taxes in cash within the prescribed period following the tax levy. In one county in Iowa, where a large percentage of the taxes are always paid shortly after being levied, the county auditor who has charge of the tax levies always sends a letter to each landowner calling his attention to the economy of immediate payment. When the landowner understands that it will be necessary to issue bonds if his drainage taxes are not paid within the prescribed time after they are levied, and that then he must pay not only the taxes levied but also the interest on the bonds, he will make an effort to pay his drainage taxes before bonds are issued.

TAXES PAYABLE IN ANNUAL INSTALLMENTS.

The laws of many States provide that taxes remaining unpaid shall be collected each year in amounts equal to the face of maturing bonds and interest due that year. Unless the law requires that the taxes be paid in equal annual installments, they should be so divided as to make the smallest installments fall due at the time the property owners, under normal conditions, will be receiving the smallest return from the lands. This period ordinarily is the first two to five years after the taxes are levied, as usually it takes several seasons after the improvements are completed to put the land in a good state of cultivation. Then, too, as taxes are paid off each year the amount of outstanding taxes becomes smaller, with a corresponding reduction in the amount of interest which must be collected.

Another point must be considered in connection with the final installments before determining during what years the heaviest taxes should fall due. Like others, drainage improvements deteriorate in usefulness each year and hence require maintenance and repairs. To make these repairs the laws provide for levying annually a maintenance tax in addition to the regular taxes. While few districts have done this, it is a practice which should be adopted generally.

Whether the taxes extend over a period of 10, 20, or 30 years, three factors should be considered carefully in fixing the amount of unpaid taxes to fall due each year. These are: (1) Small return from the land in the early years, (2) heavy interest charge on unpaid taxes during the early years, and (3) deterioration of improvements. In districts where it is practically certain that all the land can be put under cultivation almost immediately after the improvements are constructed, payment of the final installment of taxes at an early date is desirable. In the majority of districts the taxes to retire the bonds are paid in 10 annual installments.

FINANCING OF DRAINAGE DISTRICTS.

There are three methods of financing drainage districts:

1. Each landowner pays his share of the cost in cash in advance of construction.
2. The district issues certificates or script.
3. The district issues bonds.

CASH PAYMENTS.

This method is used seldom, because it is not practicable except in sections where the landowners are financially able and the districts embrace but a few hundred acres. As pointed out, one reason for the formation of drainage districts is to furnish a method whereby the landowners may spread the payment of costs of improvements over a number of years.

CERTIFICATES OR SCRIPT.

Issuing certificates of indebtedness due at such times as it is expected the district will have funds generally is not to be recommended and seldom is done, because these certificates usually must be sold for less than their par value. Further, those bidding for the contract will make inquiry, before submitting their bids, as to whether they are to be paid in cash or by certificates or script. If the contractors are to be paid in script, they usually will make their bids considerably higher so as to allow for the necessary discount they must accept if they attempt to cash the certificates. Of course these certificates are so arranged as to mature by the time the annual taxes are collected, and they bear interest from the date of issue until paid; but the contractor is not in the investing business. In States where county officers have charge of the administration of drainage districts and issue the certificates in the name of the county, the financing of districts by certificates works out somewhat better.

BOND ISSUES.

Financing by issuing bonds is the method most generally practiced and is followed almost exclusively in the larger districts.

After the time within which taxes can be paid in one amount has passed, which is seldom less than 30 days, the commissioners arrange to sell the district bonds amounting to the difference between the total tax levy and the amount paid in cash. This action is necessary to obtain cash to carry on construction work. Of course until all the bonds are paid they draw interest, and this is why the landowners must pay interest on unpaid drainage taxes. These bonds usually extend over a period of 10 to 20 years.

Factors determining maturity of bonds.—Generally no part of the principal of the bonds is paid until the end of the third or fifth year. The time when the first installment of bonds shall fall due should be determined by the merits of each project—that is, its earning power. Most laws state that it shall not be later than the end of the fifth year. If as much as 75 per cent of the land in the district is under cultivation before making the drainage improvements, it usually is safe to say that the district should be in a position to pay off some bonds at the end of the second year. If none of the bonds can be retired at the end of the fifth year from date of issue it is questionable whether conditions are such as to warrant drainage of the lands at that time. Care must be taken to see that the date of the first maturity is not too early, for the landowners should have the opportunity to harvest at least one or two crops before they are called upon to pay any of the bonds.

It is now generally agreed that the life of a drainage improvement should determine the length of time over which the bonds should extend. The life of a drainage improvement varies, depending much on the nature of the soil and the character of improvements constructed. It has become the general custom to have the last series of bonds mature not later than the twentieth year, and in many districts the bonds are all paid in the course of 10 or 12 years. Just when the first and last series of bonds should mature, and in what amounts, are questions which must be determined in accordance with the provisions that have been made for collecting taxes. Those charged with preparing the bonds should see to it that they do not fall due before the date on which taxes become delinquent, otherwise the funds on hand may not be sufficient to pay the bonds and interest. It would seem unnecessary to call attention to such a matter, yet such cases have occurred. In one instance the bonds and interest fell due in August, while taxes were not due until the following December. The district officials should give this matter very careful attention.

Amount of bond issue.—In some States recently enacted laws contain a provision limiting the amount of bonds which may be sold to 90 per cent of the total amount of taxes levied. This limitation adds to the marketability of the bonds and seems a wise precaution. By thus collecting more taxes than are necessary to pay the maturing bonds, in case some landowners do not pay promptly or it becomes necessary to sell lands for taxes, there will be on hand enough money to permit bonds and interest to be paid promptly, which is highly essential. Nothing has so evil an effect upon drainage reclamation, or so adds to the difficulty of selling drainage district bonds at a fair, reasonable price, as the failure of a few districts to make prompt payment of bonds and interest as they fall due. Of course, the limiting of the bond issue to 90 per cent of the taxes levied does not mean that the landowners will receive only 90 cents for each dollar they pay in taxes. As years go on the funds on hand will increase, and when the last installment of taxes must be collected it can be reduced by the amount of the surplus on hand. In certain districts now in existence, if taxes continue to be paid as they have been in the past, it will not be necessary to collect the last installment of taxes, and only a part of the next to the last.

From what has been said regarding the use of surplus in case certain landowners do not pay their taxes, it should not be inferred that the landowner who pays his tax promptly must pay for the one who does not. The law makes the drainage tax a lien on each tract of land against which an assessment has been made, and no indebtedness against the land except general State, county, school, and road taxes can be satisfied before the drainage tax. Practically all laws contain provisions for rigidly and promptly enforcing the payment of drainage taxes, and for heavy penalties which attach as soon as taxes are past due.

It might be inferred from what has gone before that the amount of taxes which can be levied is determined some time in advance of the issuance of bonds. If the drainage commissioners proceed in the order prescribed by the law this would be the case, but frequently the total amount of taxes levied and the amount of drainage bonds to be issued are determined upon at the same time. In districts where this method is followed the amount of taxes levied should be 10 per cent greater than the actual estimated cost of the improvements, and bonds should not be issued in excess of 90 per cent of the taxes levied. Particularly should these precautions be taken in States where no limitation is placed on the amount of bonds which may be issued. There have been cases in which bonds were issued to cover not only the cost of construction of the system but also the interest which would fall due on the bonds during the several years next after their issue. Such procedure requires the landowner to pay interest on interest. If the laws do not require the landowners to pay any tax during the first several years, then interest on bonds during this period must be included in the original bond issue; otherwise there would be no funds to pay the interest as it fell due. Such financing, however, is expensive and should not be practiced if it can be avoided.

Type of bonds.—Drainage bonds now are generally of the serial type; that is, a certain number fall due each year. The good feature of this type of bond is that as the district pays off bonds the landowner is relieved of the payment of further interest. As the investing public prefers a bond with interest payable semiannually, drainage bonds should comply with this demand. Such a bond will find a much wider market and command a better price than one on which the interest is payable but once a year.

Interest rate of bonds.—When it comes to determining what rate of interest bonds should bear, a question is presented on which most drainage commissioners would do well to consult reputable, responsible bonding houses. Usually the laws prohibit the sale of bonds bearing more than 6 per cent interest. There may be those who think that the landowners would pay less interest if the bonds carried 5 per cent interest, but the district might be obliged to sell such bonds at a discount that in the end would make them considerably more expensive to the landowners than a 6 per cent bond. Again, there may be others who argue that if the bonds paid 7 per cent interest they could be sold at a premium, but this does not follow necessarily. The individual investor in bonds looks with suspicion on any bond bearing 7 per cent interest; he concludes there must be elements of risk in it which he does not care to take. As the bond house in turn disposes of all bonds it purchases, it realizes that it will be more difficult to sell a 7 per cent bond than a 5 or 6 per cent bond, and naturally it will not offer any more for a 7 per cent issue than for one bearing a lower rate. In fact, many bond dealers say they would pay less for a 7 per cent drainage bond than for a 6 per cent bond, and many others will not purchase the former at any price.

In some States drainage districts can dispose of bonds yielding 4½ per cent and 5 per cent interest at a premium, while in other States bonds bearing 6 per cent must be sold for less than par. The principal reason for these differences is the condition of the bond market and the character of the district offering the bonds. The first condition the drainage commissioners can not control, but by consulting responsible dealers in bonds they can learn whether the money market is such that a bond issue can be marketed at a reasonable price at the particular time. The second condition depends upon the merit of the project itself and upon the manner in which its affairs have been administered from the beginning.

Sale of bonds.—The important principle to be observed in negotiating a sale of bonds is to deal with none but reputable, responsible persons who are financially able to purchase the bonds of the district.

The laws of a number of States require that drainage bonds shall not be sold below a certain amount, while others permit the commissioners to sell the bonds at the best price obtainable. Whatever the law may require, it generally is admitted that the condition of the money market and the character of the security offered in a large measure control the price at which a drainage district or any other enterprise can dispose of bonds.

The best the drainage commissioners can do, so far as the money market is concerned, is to study its condition carefully at the time the commissioners are considering the issuance of bonds. In this study the commissioners can secure valuable assistance from any responsible bonding house. It always is well not to confine investigation to only one or two financial institutions, nor should it be limited to those in the same city.

As to the character of the security offered, the drainage commissioners, by attention to details, by endeavoring to maintain good feeling and interest on the part of the landowners, and by insisting that the attorney take every precaution, can do much to make the bonds command a good price. What frequently is termed a "good law" can not, in itself, make a bond an attractive investment, and unless the bonds look attractive to the man who finally puts his money into them, no drainage district can expect to command a reasonable price for them. The landowners themselves, by cultivating all the land available at the time and by practicing the more approved agricultural methods, can do much to make the bonds attractive. For instance, in certain States, even when the money market is unfavorable, drainage bonds always command a premium; while in other States, even with a favorable market it is difficult to sell them at par, though the laws in some of the States in the latter group may be even more rigid in enforcing the collection of taxes than are those in the States of the former group. The principal reason for the difference seems to lie in the moral responsibility of the landowners for their debts, and the kind of agriculture practiced in the one group of States as compared with the other.

In selling drainage bonds one of two methods usually is followed. Either the drainage commissioners negotiate personally, more or less privately, with a few bonding houses, or by advertising they invite bids from responsible parties. The latter method is the more generally practiced, especially in the case of districts having a large bond issue. The former method is objectionable and should not be practiced, since the number of houses approached usually is very limited, a condition which obviously results in limited competition and usually means that the district does not realize as much for its bonds as it would if more houses were competing for them. In some sections there has been a tendency to negotiate with one house only. This is exceedingly objectionable, because the district is more or less at the mercy of the house with which it is dealing, and it fails also to get the benefit of valuable suggestions which would be secured by negotiating with a number of houses. Communication with these bond houses should be opened some time before the commissioners arrive at the point where they are ready to issue bonds. In addition, they should advertise in some of the leading financial papers, inviting bids on the bonds when they are ready for sale.

As an illustration of the evils of dealing with only one house, one district was induced to issue $108,000 in bonds to finance work to cost only $78,000, the money to remain in the hands of the bond house and be drawn at the rate of $4,000 a month. It required eight months to start the work, and the bond house had the use of the entire amount without interest, while the bonds were drawing interest that the landowners had to pay. In addition, they had to pay the cost of printing the bonds and for the opinion of the bond house attorney who passed on the legality of the issue.

Another phase which generally needs consideration in cases where bonds are sold without inviting bids is that of agreements for the purchase of the bonds into which many of the bonding houses insist that the drainage district shall enter. These contracts should be examined carefully by the district's attorney. One clause which usually is inserted in such agreements is to the effect that the bonds will be purchased subject to the approval by the bond-house attorney of the proceedings under which the bonds are issued. As no district wishes to sell bonds that are not legal, the provision is a proper one to protect the bonding house, provided it is not abused; but the temptation to take advantage of this clause is not always successfully resisted. One instance will suffice to illustrate the possibility of its abuse. By an agreement containing such a provision a district had contracted, at a time when the bond market was strong, for the sale of its bonds at a certain price. The bonds, however, were not ready for issue until some time afterward. In the meantime the bond market had weakened to such an extent that the bond house felt it could not handle the bonds profitably. Accordingly, the bond house notified the drainage district that its attorney would not approve the proceedings and therefore it could not purchase the bonds. Later, the district submitted a copy of the proceedings under which the district was organized to the attorney usually employed by the bond house; his opinion was that the proceedings were legal. As before stated, no objection is found to the insertion of a legality clause in an agreement for the purchase of bonds, but it should be inserted in good faith. It would seem that there might be less chance for abuse of such a provision if the clause specifically mentioned the attorney who is to pass upon the proceedings. The contract also should require the bond house to purchase the bonds within a certain time after issue or forfeit its right to purchase.

DEPOSITORY FOR PROCEEDS OF BONDS.

When bond houses are negotiating for an issue of drainage bonds they wish to know where the proceeds of the bonds will be deposited by the district. A few years ago it was the almost universal custom for the commissioners to insist that the funds be turned over to them to be deposited where they saw fit. Usually local banks, to obtain these funds, would offer high rates of interest, 5 and 6 per cent being not uncommon. Of course the local banks loaned out the money at still higher rates. Unfortunately some of these banks frequently were concerned more in the interest returned on the money than in its safety, or they did not possess the necessary organization to make a thorough examination of the security offered. This depositing of the proceeds of bond sales in local banks proved unsound, and in a number of instances disastrous. One district which had deposited $330,000, lost $300,000; another lost $90,000, and another $60,000. The funds of one district were saved through its attorney, who had learned that the bank was in trouble and immediately withdrew them. The next day the bank closed its doors.

In each of the above districts personal bonds were given, but when the time came to enforce them they were worthless. It may be argued that these losses might have been prevented if the banks had been required to furnish bond by a responsible surety company; this doubtless is true, for no responsible surety company would have given a sufficient bond to these banks. Such refusal to furnish a bond would have suggested at once to the drainage commissioners the danger of depositing with the local banks.

The commissioners should not be tempted by high interest rates. The purpose of a drainage district is not to make money but to construct drainage improvements; therefore, the district's funds should be so invested and protected that they will be available as construction progresses. In determining upon a depository it would seem that the commissioners, in the absence of statutes on the subject, would be acting in the interests of the district by arranging to deposit the funds in that bank which would pay the highest rate of interest and which could furnish a satisfactory indemnity bond by a financially responsible surety company guaranteeing the funds against loss. To remove the temptation to deposit the proceeds of bonds in questionable banks paying high interest rates, some of the drainage laws have been so amended as to prohibit depositing funds in banks paying more than 4 per cent interest.

In recent years the custom has become quite general to deposit the funds in a large banking institution located in some money center, the district receiving certificates of deposit bearing a fixed rate of interest. This institution is required to furnish an indemnity bond executed by a first-class surety bond house. The certificates of deposit are made so as to mature as it is expected the needs of the district will demand. The account should be in the name of the drainage district and not in that of any individual officer of the district, and it should be subject to be drawn upon only by the proper officer of the district. If the bonds are issued by county officials the proceeds should be deposited to the credit of the district and not with the county funds, for in the latter case the county would receive the interest, whereas it should belong to the district.

USE OF THE FUND.

The money secured from cash payment of taxes and the sale of bonds is to finance the project, which includes organization, administration, and construction expenses. None of this fund should be used for constructing ditches or other improvements which were not included in the plans finally approved by the commissioners and the court. In fact, to divert the fund from the use for which it was raised to some other purpose is illegal. Further, it has been held that where the commissioners diverted funds raised by special assessment for the improvement of a portion of the main ditch to other ditch work, they had no power to levy an additional assessment to replace the fund thus diverted.

PAYMENT OF BONDS AND INTEREST.

COLLECTION OF TAXES.

The only method of raising funds for the payment of bonds and interest as they fall due is by collecting taxes. The method of levying taxes has been discussed, but the prompt collection and the proper use of them are as important as the levy. Whether the taxes levied against each tract are spread at one time over the whole period during which they are to be paid or only from year to year, the commissioners should see to it that the tax collector is furnished in ample time with a list showing the drainage taxes to be collected from the various landowners in the district. In the best administered districts the proper officials personally prepare these lists so as to avoid any errors. It always is advisable for those who have charge of spreading the levy, especially in the case of a new set of officers who have entered upon their duties recently, to check the annual total tax levy against the total amount shown by the bond register to be needed that year to retire maturing bonds and pay interest on outstanding bonds.

If no bonds fall due during the earlier years, then, unless the law requires otherwise, the taxes levied should provide for no more than interest on the bonds. In some States where county officials serve as the officials of drainage districts the practice prevails of collecting an equal amount each year, though bonds may not fall due until the close of the third year. If the excess above interest requirements were put out at interest for the district, this practice might not be condemned, but usually this excess is merged with the county fund and the county gets the benefit of the interest. This practice certainly does not do justice to the landowners.

Usually drainage taxes are collected at the same time and by the same official who collects State and county taxes. In a few instances, however, the district has its own collector. In the latter cases, for the convenience of the landowners, arrangements sometimes are made with local banks for the payment of taxes at those institutions. Whatever method be followed, the landowners should be reminded when they are notified of the amounts due that severe penalties are attached to drainage taxes if they are not paid when due, and that property can be sold for nonpayment just as for other taxes. Large districts which issue reports to the landowners at stated intervals would do well to emphasize in these reports the necessity for prompt payment of taxes. Landowners not residing in the district should be notified in ample time of the amount of their taxes. It is among these landowners that delinquencies most frequently occur, usually because they are not kept in close touch with developments.

DISPOSITION OF TAXES COLLECTED.

Within a reasonable time after collection of taxes the collectors should be required to transfer all drainage moneys to the drainage district treasurer, from whom they should receive a receipt. If these funds are not received by a certain time, it becomes the duty of the treasurer of the district to make immediate inquiry as to the reason for the delay and to demand the funds. It will not do for the treasurer to delay in making this inquiry, neither can he accept excuses, for at a certain stated time the bonds and interest become due and must be paid, and it is the treasurer's duty to see that funds are on hand for this purpose.

If the bonds and interest coupons are payable at some bank in a money center, which generally is the case, the treasurer should exercise every precaution to see that sufficient money is at the bank in ample time. Carelessness in forwarding funds to the paying bank has caused delay in a number of instances in the payment of both interest and principal, though the taxes actually had been collected and turned over to the treasurer of the district. If the districts involved through carelessness in forwarding the money were the only ones to suffer, such cases might be overlooked; but the failure of one district to meet its bonds and interest when due affects the market for the securities of drainage districts generally. In recent years the drainage statutes of some States have been amended so as to impose severe penalties on officials who fail to perform their duties promptly.

In this matter of carelessness with funds for the payment of outstanding bonds the drainage officials are not alone. There also have been cases where the funds were forwarded to the bank in ample time, but through carelessness of the bank's employees the drainage districts were not given credit promptly. In one case the draft of the drainage district was with the bank at least 10 days before the time for paying interest coupons, and in another at least three days and yet the coupons were marked "no funds" and returned to those who presented them. The district is powerless to guard against such carelessness. However, mention is made of it because the opinion is entertained generally that when delays occur the drainage districts solely are to blame. In such cases, while the fault lies with the bank, the unfortunate part is that drainage districts, as far as the investor is concerned, must suffer.

It sometimes happens also that the proceeds of the bonds sold do not furnish money sufficient to complete the improvements. The temptation then arises to use for completing the work some of the money collected in the form of taxes. It must be remembered, however, that this money is collected to pay interest and principal of bonds as they fall due, and a sufficient amount of the taxes collected must be set aside in a separate fund for that purpose. Again, as sometimes happens, funds are needed for maintenance purposes in portions of the constructed work before the entire project is completed. In such cases the same temptation again arises. Nothing but a shortage of funds to meet principal and interest of bonds can result from a diversion of money raised by taxation to construction and maintenance purposes, and therefore under no circumstances must any such diversion be made. If sufficient funds have not been provided to complete the improvements, or if maintenance work becomes necessary, all laws provide methods for raising the money needed.

RECORDS OF DRAINAGE DISTRICTS.

Prior to this the thought must have suggested itself that to promote and administer drainage districts properly some system of records is essential. Just what form these records should assume or how detailed they should be is a matter for the commissioners of each district to determine. A system of records necessary in a district costing a million or more dollars would be unnecessarily detailed, complicated, and expensive for a district costing much less. What is needed is a set of records from which the true condition of the district may be ascertained readily. The records relating to the legal phases of the district frequently are kept by its attorney, but these should also appear properly arranged and complete in the files of the district, as they form part of the records of the district.

DRAINAGE RECORD.

A full and complete record of all proceedings relating to the drainage district, including oaths of officers and all contracts, should be entered in the drainage record. As the attorneys to whom the bonds are submitted for approval require affidavits with regard to publishing, posting, and serving notices, such affidavits should be secured at the time the notices are published and should be a part of the drainage record. No action should be taken by the commissioners unless through the form of a resolution. Especially should every authorized expenditure be supported by a resolution, and all such resolutions should be entered in full. All agreements in settlement of damages, contracts with attorneys, engineers, contractors, and bond houses also should be entered in detail. Under many of the laws every action the commissioners take must be entered in the record. In States which do not require the entering of all actions it is highly desirable that the affidavits, agreements, and contracts above mentioned should be recorded in full, and that the drainage record should contain authority for every entry made in the various accounting records.

ACCOUNTING SYSTEM.

When it comes to determining upon a system of accounting for the district there always is a possibility that the officials of the district will run to extremes. Either the records are so few and the forms so poorly adapted to the needs of the district as to render them practically useless. or they are so numerous and detailed, and perhaps poorly designed, as to make them both unsatisfactory and highly expensive. The accounting methods of the district should be based on sound accounting practice. As it happens frequently that the treasurer of the district, who usually is the accounting officer, is a landowner in the district who knows little or nothing of accounting methods, the records which it is decided to use should be so simple that they can be understood by the average person. They also must be sufficiently detailed to show the real financial condition of the district at all times. That system of accounting which is simple and composed of few records and yet always shows the true condition of the district therefore is the best. In many of the larger districts it has been found economical to employ public accountants to design the accounting forms and to instruct the accounting officer of the district in the use of the forms.

Whether the district costs only a few thousand or several million dollars, it is felt that at least the following records or books should be used in every district:

1. Book of receipts and disbursements.
2. Check or warrant book, supplemented by a petty cash book.
3. Bank book in district's name.
4. Full and complete assessment register.
5. Bond register.

Book of receipts and disbursements.—The book of receipts and disbursements operates on the same principle as an ordinary cash book. For convenience, it is well to distribute disbursements to the following items:

1. Construction.
2. Administration.
3. Retirement of bonds.
4. Interest on bonds.
5. Maintenance.
6. Miscellaneous expenses.

Each of these items is self-explanatory. Some question, however, might be raised as to whether engineering supervision of the construction work should be charged to the "construction account" or to the "administration account." As far as the financial condition of the district is concerned, it can make no difference, but for convenience, if charged against construction, it should be so separated from the contractor's account that the actual amount paid to the contractor may be ascertained easily.

Check or warrant book.—As a check against expenditures, all disbursements, except for small items, should be made by checks or warrants, which should show on their face the amount for which they are drawn, to whom they are payable, and for what purpose. It is in the interest of good administration to pay small items of expense in cash. The fund for paying these small items should be secured at such times as the treasurer may need money.by drawing a check for a lump sum to his order. To substantiate such disbursements, the treasurer always should demand bills properly receipted. When it becomes necessary to replenish his fund he should present an itemized statement, accompanied by the receipts, to the drainage commissioners and have them make another check in his favor. All canceled checks or warrants should be preserved carefully.

Bank book.—All money received should be deposited in bank daily. Under no circumstances should it be disbursed without being deposited. A local bank of good standing can be used for making these deposits. The books needed for recording deposits will be furnished by the bank. These daily deposits will not be large except when the annual receipts from taxes are being turned over by the collector. As it always becomes necessary shortly after taxes are collected to forward money to the institution paying the maturing bonds and interest coupons, the chances of loss by using the local bank for this purpose are small.

Assessment register.—As soon as the drainage commissioners have determined over what period unpaid taxes shall extend, and in what amounts bonds shall mature, a full and complete assessment register should be prepared showing the taxes assessed against each piece of property and the total amount of taxes to be collected each year. Provision should be made in this book to give proper credit to the landowners as taxes are paid.

Bond register.—The bond register should show by years the total amount required annually to meet interest due on outstanding bonds and the total number and amount of bonds to be retired each year. If this book is consulted and compared with the assessment register before submitting the drainage tax list to the collector there should be little opportunity for making an error. Where a county official is required by law to act as secretary or treasurer of a drainage district the drainage commissioners should endeavor to prevail upon him to keep the records of the drainage district independent of general county records, and also to keep all drainage funds independent of county funds.

Annual audit and report.—Under many of the laws the drainage commissioners are required to submit to the court an annual report of their activities, accompanied by a statement showing receipts and disbursements and the financial condition of the district on the day the statement was prepared. Other laws require that the commissioners shall have the books of the district audited annually by competent public accountants, whose report shall be made public to the landowners at an annual meeting to be called by the commissioners. Whether the law requires it or not, the value to almost any district of such an audit and its publication is apparent, since it serves as a check on the officials and tends to make them do things in a business-like manner. Then, too, it serves to inform landowners of the progress that is being made and to keep them interested in the project, and anything which keeps the interest of the landowners in a drainage district should receive every consideration. Again, many clients of bond houses feel that the proceeds of the bonds may not be applied properly, and hence they do not wish to purchase drainage bonds, but it has been said by representatives of bond houses that when their clients are informed that an annual audit will be made by disinterested public accountants the investors invariably are satisfied. If the drainage commissioners, in negotiating with bond buyers for the sale of the bonds, will inform these buyers that a public accountant will audit the books of the district annually, it is highly probable that the bonds will command a higher price.

ADMINISTRATION OF DRAINAGE DISTRICTS.

SELECTION OF DRAINAGE COMMISSIONERS.

Under laws requiring county officials to act as drainage officials the property owners have no choice in the selection of officials except through the general election of county officials. In States where the property owners in each district select their own drainage officials the board of drainage commissioners usually is composed of three or five resident landowners. The commissioners select a president, a secretary, and a treasurer from their own number, except in States in which the office of treasurer is filled by the county treasurer.

Frequent reference has been made to the drainage commissioners and other officials into whose hands the administration of the district is intrusted, but nothing has been said concerning the qualifications of the persons who should be selected for these positions. Unfortunately, in too many instances little attention has been given to this selection, the opinion prevailing that the administration of a drainage district does not require men of ability. There also has been a tendency among those having the largest holdings to use their influence to place themselves on the board of commissioners, quite forgetting that the mere fact that a man has large holdings does not necessarily qualify him to serve as an officer. When landowners realize fully that a drainage project may be sound from an engineering and economical standpoint and still fail because the administration of its affairs has fallen into incompetent hands, greater care will be exercised in selecting the commissioners. It requires something more than a good project to make a success. Poor management will wreck the best drainage district as surely as it will a large commercial or industrial enterprise. The one great criticism that is made against drainage districts by investment bankers who purchase drainage bonds and by prominent attorneys who pass on their legality is that the administration too frequently is incompetent.

When it comes to selecting the persons who are to serve as drainage commissioners the landowners should make a canvass of their number with a view to selecting only the most competent. In making this selection, the business capacity of those under consideration, the manner in which they handle their personal affairs, their integrity, their reputation for meeting personal obligations promptly, the confidence the people generally place in them, their ability to adjust differences, and such other considerations as stamp one man as being a superior executive should be weighed carefully. Another highly essential quality which should be sought in those who are to serve as drainage commissioners is their capacity to forget personal interests and to view their own holdings solely on the same basis as those of other landowners.

To these qualifications should be added impartiality and courage in the performance of duties. There may be times when the members of a drainage commission may be approached by friends seeking certain favors, but the commissioners must not only be fair in all their dealings and extend no favors, but they must have the courage to enforce the law in all cases, especially those sections which relate to the collection and payment of taxes.

When bankers find commissioners possessing qualifications such as those enumerated in charge of the affairs of drainage districts, they at once have confidence in the project and will pay a larger price for the bonds than when they find persons administering the district who are insincere, unsound in judgment, and irregular and unsystematic in the conduct of their own affairs.

DUTIES OF DRAINAGE COMMISSIONERS.

It may be said in a general way that the duties of the drainage commissioners are to administer the district in accordance with the law. Under many laws the commissioners are permitted to select a secretary and treasurer, the two offices usually being filled by the same person. When the selection of this official is not confined by law to a member of the board or to some one among the landowners, the commissioners should be free to go outside the district if they feel that a more competent person can be obtained by so doing.

In the selection of an engineer to design the improvements and of contractors to construct them, the commissioners should make every effort to secure as competent and responsible persons as are obtainable with the money at their disposal.

Under many of the laws the drainage commissioners are required to advertise for bids before awarding the construction work. Frequently all the law requires is that such notices be given in local papers. That the district may receive bids from concerns which are equipped to do such work on a large scale and at a minimum price, the required notice should be inserted also in at least one or two magazines or journals devoted to the interests of engineering and construction work. Even if the law does not require the commissioners to advertise for bids covering the construction of the improvements, it always is advisable to do so. These advertisements should state that all bids received will be opened in public on a fixed day at a certain place. The commissioners should reserve the right to reject any or all bids. If the commissioners decide to award the contract to one of the bidders, they should make such award as soon as practicable.

The commissioners should insist that adequate bonds by financially responsible surety houses be furnished by the treasurer, engineer, contractor, and any banks or other institutions which may be used as depositories of the district's funds. The matter of contracts with the attorney, engineer, contractor, and others has been discussed.

When about to sell an issue of bonds the commissioners should invite wide competition. This can be done by advertising for bids in some of the leading financial journals or by communicating directly with reputable investment bankers who deal in drainage bonds. It makes little difference which method is followed so long as competition is not limited to a few.

The work of the commissioners in connection with assessment of benefits has been discussed. The levying of taxes regularly and the enforcement of their prompt collection are subjects to which the commissioners should give close attention. Bondholders can look to none but the commissioners for their interest and principal; hence it is the commissioners' duty to see that tax collections are made promptly and the funds placed in the hands of the proper parties for disbursement. The commissioners are the custodians of the welfare of the district. It is their duty not only so to administer the district as to be able to sell bonds at a good price and to see that construction is well performed, but also to see that the credit of the district always is maintained and that its bonds always are paid promptly. In the interests of drainage districts generally, the commissioners of no district can afford to permit a failure of payment of interest coupons and bonds as they mature, for, as was recently said by an eminent financier: "The man who has been disappointed in his hope of a safe and paying investment, for whom either principal or interest fails, who in time of need is obliged to sell out at a loss, has a long memory, an easy tongue, and a bitter heart."

The drainage commissioners alone are responsible for the proper use of the fund, and, therefore, they should see to it that such records are kept as will enable them at all times to ascertain exactly the financial condition of the district. Not only should the records give this information, but they should be orderly and bear evidence that the man back of them is equal to the position. This may seem a small matter, but its effect will be reflected in the price the district will be offered for its bonds.

NECESSITY FOR ADEQUATE MAINTENANCE.

Finally, as custodians of the drainage system, the drainage commissioners should remember that a drainage system is a "wasting property"; that is, it deteriorates in efficiency as time passes. This suggests the necessity of provision for adequate maintenance and repair. The efficiency of the system as constructed will be maintained considerably longer in a district in which the commissioners have taken precautions to see that undesirable refuse from adjoining lands, which would obstruct the flow, has not been dumped into the ditches. Again, the necessity of maintenance can be delayed if the drainage commissioners will instruct landowners in the proper methods of constructing farm bridges across open ditches and of constructing outlets of open and tile drains into the main ditches. In one of the largest districts in the country the drainage commissioners have found it to the interests of the district to have plans prepared by its engineer showing how to construct bridges and outlets. Copies of these plans are posted at various public places in the district, and are also sent to landowners upon request.

Under most laws the drainage commissioners are charged with the duty of maintaining the main ditches in an efficient state.

The rapidity of deterioration in open ditches varies in different sections, but if the bottoms and sides of the ditches are permitted to grow up with weeds, brush, and saplings, experiments show that the efficiency of the ditches is decreased as much as 35 per cent. When once deterioration starts it progresses rapidly. The preservation of drainage improvements, therefore, should begin when deterioration first becomes noticeable. The drainage commissioners should have the engineer inspect all ditches annually and submit an estimate of the amount needed for proper maintenance. A tax to be known as a "maintenance tax" should be levied. The funds collected for this purpose should be kept separate from and accounted for independently of other drainage taxes and funds. The failure of the commissioners to keep the drainage improvements in proper repair will have the result that the landowners will not receive the benefits which otherwise they would receive, and this in turn will cause the landowners to become dissatisfied and pay their taxes grudgingly. Both the commissioners and the landowners must remember that if full benefits are to be derived from drainage it is just as important to maintain the system properly as it was to construct the system in the first place. Constant inspection and maintenance must follow construction, otherwise, in the course of time, the money spent on construction will cease to give returns.

SUMMARY.

Before promoting a drainage district consideration should be given to the economic conditions prevailing in the section in question, the agricultural value of the soil, and the demand for more agricultural land on the part of resident landowners. The cost of draining the land as compared with the market prices of other lands possessing equal agricultural value and not needing drainage should be learned. The sentiment of the property owners toward drainage should be ascertained. The success of the project requires the cooperation of more than a bare majority. Unless funds sufficient to construct adequate improvements can be obtained, the undertaking of the project generally would not be warranted. Incomplete or inadequate drainage works are invariably a poor investment. In determining these factors it should not be forgotten that every project which is possible from an engineering standpoint is not necessarily economically practicable under existing conditions.

The organization of drainage districts for agricultural purposes is made possible by special laws which prescribe the various steps to be taken. Since drainage districts come into being only through the law, it is highly essential that the law be complied with in every detail. The need of retaining a competent attorney is apparent at the very beginning.

The three principal reasons for forming a drainage district of wet lands which it is desired to reclaim are:

1. To provide a method of equitably distributing costs among the landowners and a means of collecting such taxes.
2. To issue bonds to finance the district.
3. To obtain authority to condemn whatever land may be needed for the general use of the district.

Each of these factors is vitally important to the promotion of the project. The second factor relies on the first to the extent that only through a legal distribution of costs and prompt collection of taxes can funds be raised for paying the bonds at maturity. Drainage bonds have no value unless there is some legal method of enforcing their payment, and the only method the law prescribes is through the levy of taxes. Unless these taxes are enforceable the bonds must fail. The necessity of complying strictly with the requirements of the law leading up to the levy of taxes, therefore, must be self-evident. Before the first paper is prepared and filed, attorneys for districts should realize fully that each step in the procedure leads up to the issuance of bonds, and that any doubtful question of legality of the bonds which would affect their security can not be decided in favor of the district. In carrying into effect the various provisions of the law the attorneys should discard forms unless they have checked them carefully to see that they comply with the requirements of the law. Do not follow forms, but follow the law, is good advice for every board of drainage commissioners to give to its attorney when it retains him. If it becomes necessary to condemn any land, the procedure prescribed by the law must be followed in every detail.

The drainage commissioners must insist on employing the best talent they can afford to design and construct the improvements. So-called cheap engineering and construction must be guarded against. Bids for construction which on their face appear a great deal less than others should be scrutinized closely. The awarding of legal, engineering, or construction work to so-called "home firms or companies," simply because they represent home or local talent, must not be practiced. The interests of the landowners demand the best and that which is the most economical in the end. The importance of employing reputable consulting engineers to pass upon the plans before their final approval and adoption should not be overlooked.

In selecting officials to administer districts the landowners should be guided by the same principles that govern the selection of directors for successful commercial and industrial enterprises. The drainage commissioners always should remember that they are the custodians of the district and the guardians of the interests of the landowners and that all their actions should be for the welfare of the district and the property owners. To their lot falls the task of maintaining interest and harmony. In appointing engineers, attorneys, and other assistants, in awarding contracts, and in selling bonds the commissioners should so govern themselves as to win the confidence of the landowners. Above all, from their first until their last meeting, the commissioners should keep in mind that the severest criticism has been directed against the management of districts and that lax and inefficient administration always is reflected in the price paid for the bonds.

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MINOR ARTICLES OF FARM EQUIPMENT

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FEW farmers realize the extent of their investment in small items of equipment or the time and inconvenience involved in buying them singly or in small lots. In planning the farm equipment due consideration should be given to the necessary outlay for these minor tools. If possible they should be purchased all on one order. This will save time and, usually, money. Also, it will entail a total expenditure sufficiently large to impress the farmer with the importance of giving systematic care to his small tools. It is shown in this bulletin that for a general farm of 160 acres in the Middle Western States, the necessary minor tools, ranging from a husking peg to a grindstone, will cost from $100 up to the neighborhood of $200.

MINOR ARTICLES OF FARM EQUIPMENT.

CONTENTS.

	Page.		Page.
Extent of minor equipment	3	Total cost	13
List of articles	4	Advantage of making a list	14

EXTENT OF MINOR EQUIPMENT.

This bulletin presents the results of a study made to determine the number and cost of all minor articles of equipment necessary for a farm of the general type. This study did not include wagons, machinery, or other articles which, because of their bulk or value, would be classed as items of major importance, but was confined to the miscellaneous small tools, utensils, and sundries usually purchased singly or in small lots at a slight cost for each.

The total cost of these miscellaneous articles usually is much higher than the estimates currently given by farmers and writers, but, owing to the great number of small purchases, this fact is seldom realized, except by the few who have made careful inventories at stated intervals. Farmers in general neglect this valuable portion of their equipment. Indeed, the decrease in value of the small articles probably is much more rapid than that of the major items. The low current estimates on the cost of this part of the equipment inevitably cause disappointment to the manager of a new farming venture who finds it necessary to make an unexpected increase of outlay on this account, attended by a readjustment of his plans.

In selecting the minor tools to equip a farm provision must be made for the articles needed for the care and repair of buildings, fences, machinery, etc., the care of live stock, the production of crops, and the various other interests of the farm. With every change in the type of farm, involving a new combination of enterprises, a change in minor equipment will be necessary. For each of the many specialized types of farms certain articles will be needed which will not be found necessary on general farms.

To attempt to determine the equipment in small items necessary for all these special types is beyond the scope of this paper, which is intended to cover only those items found in most common use on farms of the general type. By this is meant farms of moderate size,

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NOTE.—This bulletin is practically a reprint of Bureau of Plant Industry Circular No. 44, by L. W. Ellis, the contents of which have been revised and supplemented so as to bring it up to date.

on which both crops and live stock are raised, without particular emphasis on the production or disposition of any one product.

The nature of the minor equipment will be determined largely by the character of the farm enterprises and the proximity of repair-shop facilities, while its extent may be governed by the size of the farm, the number of workmen, and the financial circumstances of the proprietor. Perhaps both the nature and the extent of the minor equipment will be influenced most by the farmer's attitude with regard to small economies and his ability to use tools to advantage.

LIST OF ARTICLES.

Following is a summary list of the inventories of minor equipment for 33 general farms in Ohio. The classification of articles as "essential" or merely "desirable," while somewhat arbitrary, is based in the main on the percentages of farms reporting the various tools. Thus, with few exceptions, no article is listed as "essential" unless found on at least 20 per cent of the farms.

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost—		
		Per article.	Of articles suggested as essential.	Of articles not essential but very desirable.
General purpose:				
Anvil	....	$7.00	....	$7.00
Auger handle	1	.20	$0.20	....
Auger bits	Set of 6.	....	2.00	....
Ax	2	1.25	2.50	....
Ax (hand)	1	.75	.75	....
Awl	1	.10	.10	....
Barrel	....	.75	....	....
Basket	....	.30	....	....
Bell (farm)	1	2.00	....	....
Bench screw	1	.60	.60	....
Brace and bits	Set.	2.50	2.50	....
Brush hook or scythe	....	1.25	....	....
Cant hook	1	1.25	1.25	....
Chain (log)	2	1.50	3.00	....
Chalk line	1	.10	.10	....
Chisel (cold)	2	.20	.40	....
Chisel (wood)	4	.40	1.50	....

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost—		
		Per article.	Of articles suggested as essential.	Of articles not essential but very desirable.
General purpose—Continued.				
Compasses	1	$0.30	$0.30	
Ditch cleaner		1.25		$1.25
Drawing knife	1	.75	.75	
Drill press		10.00		10.00
Drills	4	.50	2.00	
File (flat)	2	.15	.30	
File (round)	1	.30	.30	
File (taper)	2	.10	.20	
Forge		16.00		16.00
Grindstone	1	4.00	4.00	
Grubbing hoe		.50		
Hammer (claw)	2	.50	1.00	
Hammer (rivet)		.50		.50
Hammer (sledge)	1	1.00	1.00	
Hatchet	1	.75	.75	
Hoisting block		2.00		2.00
Jackscrew		2.00		2.00
Ladder	1	2.00	2.00	
Ladder (step)	1	1.75	1.75	
Lantern	2	.90	1.80	
Level	1	.75	.75	
Machine oil	1 gallon.	.30	.30	
Mallet (wood)	1	.25	.25	
Mattock	1	.75	.75	
Maul	1	.60	.60	
Nippers (farrier's)	1	1.00	1.00	
Oil can	1	.10	.10	
Padlock		.40		
Paint brush		.30		
Pick	1	.75	.75	
Pinch bar	1	.50	.50	
Pliers	1	.50	.50	
Pincers (carpenter's)	1	.60	.60	
Plane	2	1.25	2.50	
Punch	2	.15	.30	

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost—		
		Per article.	Of articles suggested as essential.	Of articles not essential but very desirable.
General purpose—Continued.				
Post-hole digger	1	$1.00	$1.00	....
Rasp	1	.50	.50	....
Sand sieve	....	.50	....	$0.50
Saw (buck)	....	.75	....	....
Saw (compass)	1	.30	.30	....
Saw (crosscut)	1	3.00	3.00	....
Saw (hack)	....	.50	....	.50
Saw (hand)	2	1.25	2.50	....
Saw (set)	1	.60	.60	....
Scale (counter)	....	3.00	....	3.00
Scale (farm)	....	8.00	....	8.00
Scale (spring)	1	.50	.50	....
Scale (steelyard)	....	2.00	....	....
Scratch gauge	1	.40	.40	....
Screw driver	2	.25	.50	....
Screw plate	....	10.00	....	10.00
Shovel (D)	1	1.00	1.00	....
Shovel (round pointed)	1	1.00	1.00	....
Tinner's snips	....	1.25	....	1.25
Spade (tile)	....	1.75	....	1.75
Square (bevel)	1	.40	.40	....
Square (steel)	1	.75	.75	....
Square (try)	1	.25	.25	....
Tape line	1	.50	.50	....
Trap (rat)	....	.50	....	....
Trap (steel)	....	.15	....	....
Trowel (brick)	....	.40	....	.40
Trowel (plastering)	....	1.00	....	....
Tongs	....	.50	....	.50
Tool grinder	....	3.00	....	3.00
Vise	....	5.50	....	5.50
Wedge (iron)	2	.30	.60	....
Whetstone	2	.10	.20	....
Whitewash brush	....	.75	....	....
Wire splicer	1	1.00	1.00	....

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost— Per article.	Approximate cost— Of articles suggested as essential.	Approximate cost— Of articles not essential but very desirable.
General purpose—Continued.				
Wire stretcher		$8.00		$8.00
Wrench (pipe)	1	1.50	$1.50	
Wrench (monkey)	2	.50	1.00	
			57.45	81.15
Household and farm:				
Butcher knife	2	.30	.60	
Cold frame		2.50		
Crates		.40		
Cultivator (hand)		4.00		4.00
Flat		.10		
Hoe	2	.40	.80	
Hog scraper	2	.10	.20	
Hog hook	1	.05	.05	
Kettle		2.50		2.50
Lard press and sausage stuffer		5.50		5.50
Lawn mower	1	4.00	4.00	
Tree pruner	1	1.00	1.00	
Pruning shears	1	.40	.40	
Rake (garden)	1	.50	.50	
Rake (lawn)		.40		
Sausage grinder		2.00		2.00
Spade	1	.75	.75	
Sprinkler		.50		
Trowel		.25		
			8.30	14.00
All stock:				
Broom	2	.50	1.00	
Clipping machine		10.00		10.00
Hand sprayer		.75		
Manure fork	2	.70	1.40	
Pail	3	.15	.45	

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost—		
		Per article.	Of articles suggested as essential.	Of articles not essential but very desirable.
All stock—Continued.				
Tie chain		$0.25		
Tie rope		.25		
Wheelbarrow	1	4.00	$4.00	
			6.85	$10.00
Horse and driving:				
Bit		.40		
Blanket	3	2.00	6.00	
Brush	2	.50	1.00	
Chamois skin		.50		
Clevis		.10		
Collar		3.00		
Currycomb	2	.25	.50	
Evener (2-horse)		1.50		
Evener (3 or 4 horse)		2.00		
Fly nets		1.00		
Halters	6	.75	4.50	
Jack (buggy)		.75		
Jack (wagon)	1	1.00	1.00	
Muzzle		.20		
Neck straps		.75		
Neck yoke		1.00		
Oil (harness)	2 quarts.	.25	.50	
Punch (harness)	1	.50	.50	
Riveting machine	1	.50	.50	
Rivets	1 box.	.10	.10	
Saddle		10.00		
Snaps		.05		
Sponge	1	.10	.10	
Storm apron	1	.75	.75	
Storm front		4.00		
Sweat pad		.35		
Syringe	1	.60	.60	
Tie rope		.15		

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost—		
		Per article.	Of articles suggested as essential.	Of articles not essential but very desirable.
Horse and driving—Continued.				
Whiffletree		$0.30		
Whip	1	.50	$0.50	
Whisk broom	1	.10	.10	
			16.65	
Cattle:				
Calf muzzle		.20		
Cowbell		.25		
Crate		.50		
Dehorning clipper		5.00		$5.00
Milk tube	1	.25	.25	
Tie rope or chain		.30		
			.25	5.00
Dairy:				
Can (milk)		1.50		
Churn		4.00		
Crock (milk)		.10		
Pail (milk)	2	.50	1.00	
Pan (milk)		.20		
Bowl (butter)		.50		
Crock (butter)		.20		
Scales (butter)		1.50		
Skimmer		.10		
Strainer	1	.50	.50	
Thermometer	1	.25	.25	
			1.75	
Sheep:				
Bell		.15		
Shears		1.00		

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost—		
		Per article.	Of articles suggested as essential.	Of articles not essential but very desirable.
Swine:				
Crate		$1.00		
Portable house		4.00		
Ring pliers	1	.20	$0.20	
Rings	1 box.	.10	.10	
Snout clipper		.40		
Tongs	1	.50	.50	
			.80	
Poultry:				
Coop		3.00		
Bone cutter		6.00		$6.00
Egg tester	1	.15	.15	
Feed hopper		.25		
Feed pan		.05		
Feed sieve		.25		
Fountain		.25		
Hover box		.25		
Leg bands				
Trap nest		.25		
			.15	6.00
Corn:				
Ensilage fork		1.00		
Hand planter	1	1.50	1.50	
Husking gloves		.75		
Husking peg		.10		
Knife	2	.25	.50	
Seed rack	1			
Seed tester	1	.50	.50	
Shock tier	1	.50	.50	
			3.00	

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost—		
		Per article.	Of articles suggested as essential.	Of articles not essential but very desirable.
Hay:				
Baled-hay hook		$0.30		
Carrier	1	3.00	$3.00	
Hand fork	3	.60	1.80	
Hand seeder		5.00		$5.00
Hoisting fork	1	1.25	1.25	
Knife	1	.75	.75	
Pulleys	4	.40	1.60	
Rope (1-inch)	135 feet.		6.00	
Rope (½-inch)	65 feet.		.60	
Scythe and snath	1	1.25	1.25	
Sickle		.50		
Slings		2.00		
Stack cover		8.00		
			16.25	5.00
Small grain and seed:				
Binder cover		3.00		
Cradle		5.00		
Hand rake	1	.25	.25	
Measure	1	.50	.50	
Sacks		.20		
Scoop shovel	1	1.00	1.00	
Straw fork		.70		
			1.75	
Sugar beets:				
Beet fork		1.50		
Beet hoe		.50		
Beet topper		.25		

List of articles of minor equipment found on one or more of the 33 farms.	Number needed on farm.	Approximate cost—		
		Per article.	Of articles suggested as essential.	Of articles not essential but very desirable.
Potatoes:				
Fork or hook	1	$1.50	$1.50	
Hand planter		1.75		
Scoop		1.50		
			1.50	
Maple sugar:				
Covers		.06		
Gathering pail		.75		
Sap buckets		.20		
Scoop		1.00		
Spiles		.03		
Total essential			114.70	
Total very desirable but not essential.				$121.15

The following supplemental list, prepared by sifting suggestions submitted by over 1,700 farmers scattered throughout the country, will be found to include certain tools which though not essential, perhaps, are useful items of equipment for the average farm:

Assortment of machine and carriage bolts	
Bag truck	$1.50 to $3.00
Bolt cutters	1.00 or more.
Gasoline blow torch	1.50 to 4.00
Harness and shoe repairing outfit	.75 to 2.00
Pipe cutters	.75 to 2.00
Pipe stocks and dies	2.00 to 5.00
Pipe tongs	.85 to 1.50
Pipe vise	1.00 to 2.00
Soldering outfit	.50 to 1.00
Staple puller	.75 to 1.00
Wrecking tool	.25 to .50
Total	10.85 to 22.00

TOTAL COST.

The above lists[1] are designed to show approximately what is required for a complete equipment. Under "Number needed on farm" is given for each item the average number suggested as needed on a well-equipped general farm under the conditions obtaining in Ohio.

The figures given for the first cost of the various articles will, of course, vary a great deal with the location of the purchaser and the quality of the goods. Those given here are for a fair grade of tools. Cheaper ones may be had, and the best will cost more.[2]

The total cost of the various items suggested, though it may seem extremely large in comparison with the usual estimates, is not unreasonable if a rather complete equipment is desired. Taking the grand-total inventory of items mentioned in this list for all the farms, using the first-cost prices given, and dividing by 33, the first cost for the average farm inventoried is found to be about $190. The discrepancy between this figure and that given for the total cost of items suggested, $114.70, is due to the fact that some items included in the inventory lists of many of these farms were not essential for the average farm. The list of "essential articles" indicates a rather complete farm outfit.

Neither the $190 nor the $114.70, however, includes any allowance for a stock of materials and tools for the repair of equipment. The necessary expenditure for certain of the items under "not essential" would save many trips to town for repairs and materials and would reduce the repair bill, which assumes important proportions on some farms. With these tools to work with, many jobs may be done on the farm on rainy days when the labor would not otherwise be used advantageously. Whether it is advisable to include in the farm inventory all the items listed in the last column will depend largely upon the amount of repair work to be done on the farm, the facilities for having this work done off the farm, and the mechanical skill of the farmer and his assistants. On most farms there is an abundance of constructional and repair work which can be done with the farm labor, provided they have the necessary tools to work with. This work can usually be done more cheaply with the farm labor, provided time is taken which could not be more profitably devoted to the regular farm operations. It may be safely stated that the necessary investment to secure these items is usually profitable.[1]

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[1] Not all the items listed are necessary for a satisfactory farm equipment, and on no farm were they all reported. A few articles found have been omitted as being of an extremely unusual character. Many items which might be called farm equipment because found in farm rather than in town homes are not included, the aim being to present a suggestive list of miscellaneous farm tools, etc., for the convenience of the farm manager.

[2] No attempt has been made to make these prices conform strictly to the abnormal conditions prevailing during the progress of the European war. At the time of this publication (1917) certain articles here listed were selling at prices far above the normal level.

ADVANTAGE OF MAKING A LIST.

A careful study of these lists will bring out many points worthy of consideration. To the owner of a farm who has had no occasion from time to time to collect his miscellaneous equipment and take account of its extent, this study should suggest the advisability of taking an annual inventory of the small as well as of the large equipment in order to keep track of his investment. The practice of taking an inventory, even of the larger pieces of machinery, is not as common as it should be, and in many cases where an invoice is taken the small stuff is lumped in one item. During the process of taking the inventories used in compiling this circular the owner almost invariably expressed astonishment at the extent to which his capital was invested in miscellaneous minor articles.

Tenant farmers, especially those who have frequent occasion to move, ordinarily will be found better posted than owners as to the extent of their miscellaneous equipment, and this usually will be found much nearer the actual necessities than the equipment of the resident owner. To both owners and renters, however, it is earnestly recommended that an inventory be taken for the purpose of determining the number and value of the articles on hand and that thereafter provision be made for keeping track of the various articles in a systematic manner. In this way loss through carelessness and possible theft can be detected and guarded against, while at the same time expenditures of time and money in looking for and duplicating lost articles will be reduced to a minimum, as will also depreciation on account of neglect.

These lists should prove of great value to the prospective farmer. Even to one more or less familiar with farming the compiling of a complete list of articles necessary for an average-sized farm is often almost an impossibility. The experience of men born and raised on the farm and temporarily separated from it during a college course will bear out this statement. Take, for example, the case of a man who, though in charge of an experimental farm for four years prior to taking up farming on his own account, made an initial allowance of but $25 for small tools and sundries. After going over an incomplete list similar to the foregoing he bought from a local hardware dealer a very modest lot of small tools, amounting to over $100 in value, obtaining a cash discount of 10 per cent by lumping his purchases. A similar course might well be pursued by many persons who are about to engage in general farming. As before stated, the saving effected through the merchant's discount is often considerable. In many cases it would pay interest on the investment for some years, to say nothing of the time which would be saved through having the stock complete at the beginning.

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[1] For a full discussion of the question of repairs see Farmers' Bulletin 347.

On nearly every farm some articles will be found which have been bought at second hand. No doubt a considerable saving may be effected by thus securing articles at odd times when work is not pressing. If, however, the business of the farm must be brought to a standstill while the farmer goes to a sale, it is an open question whether the saving in buying minor items in this manner will be sufficient to make up for the time spent. As a rule, these articles are summed up in the sale bill as "too numerous to mention," and no idea is given as to the exact nature or condition of the offering.

HOW TO SELECT FOODS

II. CEREAL FOODS

CAROLINE L. HUNT and HELEN W. ATWATER
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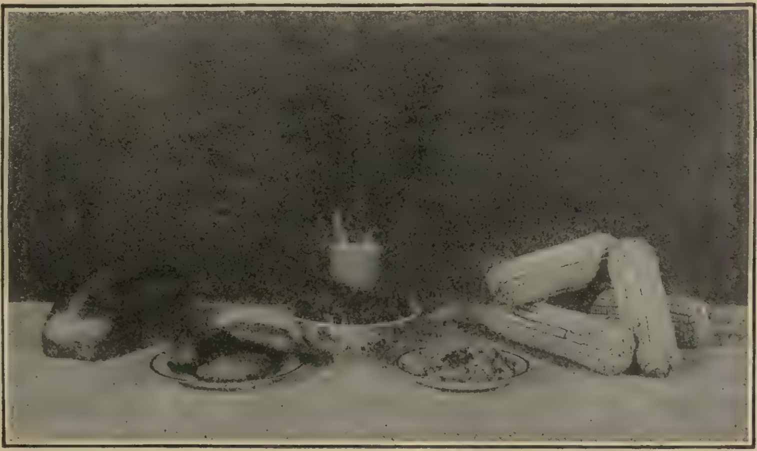

FARMERS' BULLETIN 817

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the States Relations Service
A. C. TRUE, Director

Washington, D. C. May, 1917

Additional copies of this bulletin may be obtained from the
Division of Publications, U. S. Department of Agriculture

THESE BULLETINS on the selection of food state in simple terms the main principles on which all economical selection must be based. It is not the purpose to give definite directions for obtaining food at low cost or to recommend any special foods or combinations of foods. Such rules would vary too much with locality and season to be of general or lasting value. It is simpler and more practical in the end for the housekeeper to know the general value of different foods and then choose according to that knowledge.

The present bulletin deals with foods rich in starch, and particularly with the cereals and foods made from them. These are mild-flavored, comparatively inexpensive foods which yield energy to the body. They also yield varying amounts of tissue-building and body-regulating substances. If they are combined with well-chosen materials from the other food groups, they can be used safely as the main part of the ration. With wise planning such a diet can be made adequate, attractive, and at the same time economical.

For a discussion of another phase of the subject of how to select foods see Farmers' Bulletin No. 808, "What the Body Needs."

HOW TO SELECT FOODS.[1]

II. CEREAL FOODS.

CONTENTS.

	Page.		Page.
Wise use of cereal foods	3	Cakes, pastries, puddings, sauces, and other dishes rich in cereal	16
Kinds of cereals	5	Economies with cereal foods	17
Prepared cereals	5	Potatoes and sweet potatoes used like cereals	21
Dishes made of cereals	6	Summary	21
How much cereal food should be used	8		
Bread	9		
Breakfast cereals	14		

WISE USE OF CEREAL FOODS.

In an earlier bulletin of this series[2] the diet as a whole was considered and a simple way of planning wholesome, economical, and attractive meals was suggested. The housekeeper was advised to think of the common food materials as grouped under five heads, and to make sure that the diet every day included something from each of the five groups.

The five groups are as follows:

(1) Fruits and vegetables. Without these there is danger that the diet may be lacking in mineral matter and other substances needed in the making of tissues and for keeping the body in health.

(2) Milk, cheese, eggs, meat, fish, and dried legumes (peas, beans, etc.). Without these there is danger that the diet may be lacking in protein, an indispensable tissue builder.

(3) Cereals (wheat, oats, rye, corn, barley, and rice) and their products. Without these the diet would contain practically no starch, the cheapest kind of body fuel.

(4) Sugar, molasses, sirups, honey, and other sweets. Without these the diet would be lacking in sugar, valued as body fuel and for its flavor.

(5) Fats (butter, lard, meat fat, and olive, peanut, cottonseed, and other fats and oils). Without these the diet might be lacking in fat, which has a high value as body fuel and gives to food an agreeable quality commonly called "richness."

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[1] Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.

[2] How to Select Foods: I. What the Body Needs. Farmers' Bul. 808, U. S. Dept. of Agr.

In selecting foods from any one of the five groups the following points must be kept in mind:

(1) In each group there are low-priced foods and high-priced foods. In group 2, for example, there are low-priced and high-priced cuts of meat. In many cases the cheaper cuts are just as nourishing and useful as the more expensive ones. Those who wish to economize, therefore, should choose those from which they get the largest amount of nourishment for the smallest amount of money.

(2) It usually takes more time and skill to make the low-priced foods taste good than it does the higher-priced ones. For example, the flavor of the higher-priced cuts of meat can be developed by broiling or other quick processes of cookery. The lower-priced cuts, on the other hand, are often tough and require long cooking and frequently the addition of savory vegetables or other flavoring materials.

(3) In selecting and using the foods of any group care must be taken to prevent waste. This means calculating carefully how much will be needed, and also making skillful use of foods left over.

In the case of cereals a fourth point must be considered.

(4) Where economy is especially needed cereals (the lower-priced ones, of course) should be used as freely as they can be without making the diet one-sided. In this they differ from such higher-priced foods as milk, meat, fruits, and vegetables, which, in case of need, must be cut down so far as they safely can be. To encourage the use of cereals housekeepers should—

(*a*) Provide the very best of bread; that is, bread that is well flavored, light, of good texture, and well baked.

(*b*) Take particular pains in cooking and salting the lower-priced breakfast cereals. The same rule applies to such foods as hominy, boiled rice, or macaroni, commonly served with meat or other protein-rich food at luncheon, dinner, or supper.

(*c*) Remember that, though large quantities of cereal foods may not seem attractive if served alone, they may be very appetizing if combined with small amounts of more highly-flavored or seasoned foods. A well-seasoned soup may lead to the eating of a large quantity of bread. A little savory meat or fish (salted or smoked), or a small quantity of cheese, may be used to flavor a fairly large dish of rice or macaroni.

This bulletin discusses the way in which cereal foods may be wisely used in the diet.

The term "cereal foods" may mean: (1) The kernels of corn, oats, rice, rye, wheat, etc.; (2) the flours, meals, breakfast foods, starches, etc., manufactured from them; or (3) bread, crackers, cakes, pastry, etc., in which they form an important part. It will be easier to understand their use in the diet if these three general forms are borne in mind.

KINDS OF CEREALS.

The most common cereals are wheat, rye, corn, oats, and rice. They differ somewhat in appearance, taste, and food value, but all have many features in common.

Besides the more common cereals named in the last paragraph there are a few others which may be briefly mentioned. Barley is one used chiefly in gruels or in soup. Buckwheat is not a cereal in the botanical sense of the word, but its seeds resemble the true cereals in general character and food value, so that it is usually classed with them. In this country it is chiefly used for making griddle cakes. The so-called grain sorghums (kafir, milo, feterita, etc.) are cereals, the use of which is increasing in this country, especially in the semiarid sections of the Southwest. The heavy plumelike heads are shown in the picture on the cover of this bulletin. So far these sorghums have been used mainly as stock feed in the United States, but they are also coming more and more to be used as human food,[1] as has long been common in other parts of the world.

The most abundant food material in cereals is starch, which serves the body as fuel. This makes up nearly three-quarters of most grains. The next most abundant material is protein, which supplies nitrogen for tissue building. This makes up about one-eighth of the grain. There is also a little fat, particularly in corn and oats; it is found chiefly in the germ. Another important material is the "roughage," or cellulose, which is most abundant in the skin of the grain and which gives bulk to the diet. The kernels also contain actually small, but relatively high, proportions of mineral matters needed for body building and other purposes and other substances very important for regulating body processes.

The protein is not alike in all kinds of cereals. Part of that in wheat is a tough, elastic sort, called gluten. It is because of this gluten, which can be expanded into air bubbles, that light, porous bread can be made from wheat. Rye is most like wheat in the character of its gluten, though light, porous bread can not be made from it alone. Barley, buckwheat, corn, oats, and rice are so lacking in gluten that they can not be raised by yeast (see p. 9).

PREPARED CEREALS.

By prepared cereals are meant such manufactured goods as flours and meals, cracked wheat, steamed and rolled oats, puffed or flaked grains of all kinds, macaroni and other pastes, cornstarch, etc. They may or may not contain all of the original grain, and for this reason they differ more widely than the grains themselves in appearance, composition, and flavor. The cooking which some of them undergo during manufacture also causes changes. Of course, unless something is added to them, they contain no food material not present in the grains from which they are made.

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[1] U. S. Dept. Agr. Bul. 470 (1916). Studies on the Digestibility of the Grain Sorghums.

Prepared cereals differ so much in form that their appearance gives little idea of the amount of nourishment they yield. For instance, the amount of flour which will fill a cup weighs 4 ounces; that of rice, 8 or 9 ounces; and that of flaked breakfast cereal, hardly half an ounce; and it is this weight rather than bulk or volume which indicates food value. Such differences in weight and volume must be remembered by those who wish to buy their food as cheaply as possible. Some breakfast foods retail at 48 cents a pound (15 cents for a 5-ounce package); others cost 5 or 6 cents a pound. The cheapest ones are usually those sold in bulk. The housekeeper, by grinding her own wheat, can get a cereal breakfast food for a still smaller sum. When wheat sells for $2 a bushel the cost per pound is between 3 and 4 cents. This wheat can be prepared by washing, drying, and then grinding in an ordinary coffee mill.

One of the important differences between these preparations depends on whether or not any of the outer coating of the kernel has been left in. This coating consists mainly of bulky cellulose, but it also contains a large part of the important tissue-forming mineral compounds and body-regulating substances found in the grain. When the bran is left in, the preparation is more bulky and contains more of some food elements. On the other hand, it does not always keep as well and (in the case of flour) does not make as light bread, and is not so thoroughly digested. Evidently, then, the choice of cereal foods should depend on the purpose they are to serve. If bread or breakfast cereals are used as the chief part of a meal or of a diet which does not include much of vegetables, fruits, milk, and eggs, and which, therefore, may be lacking in bulk and mineral salts, it is well to choose the bran-containing preparations. This should be especially remembered in considering the diet of children, for they need more body-building mineral compounds and body-regulating substances than adults. If, on the other hand, the diet in general is varied and if flour is to be used for cakes, pastry, and general cooking, white flour is more useful than coarser whole-wheat or graham flour.

DISHES MADE OF CEREALS.

These include porridge and cereal mush, breads, cakes, puddings, pies, etc. There are even greater differences among this group of cereal foods as they appear on the table than among those from which they are prepared, because they are made in so many different ways and combined with so many different things. The cooking has made them pleasanter to eat. It is commonly believed that they are more readily digested cooked than raw. The differences in appearance are shown in figures 1, 2, 3, and 4.

Ordinarily more or less water or some other liquid is added in cooking cereals, and the water that they thus take up makes them much bulkier and at the same time more dilute. One cupful of uncooked oatmeal or rice, for instance, cooked with three cupfuls of water gives over four cupfuls when boiled, but the water, which chiefly causes the difference, does not give to the entire four cupfuls any more body fuel or building material than was in the original cupful. Hence we must not judge the food value of cooked cereals merely by the size of the finished dish, but must remember that the raw food material has been diluted, so that a cupful cooked may have only a quarter the food value of a cupful of the raw grain. The body-building protein, which makes up about one-eighth of the raw grain, makes up only about one-fiftieth of the weight of cooked porridge.

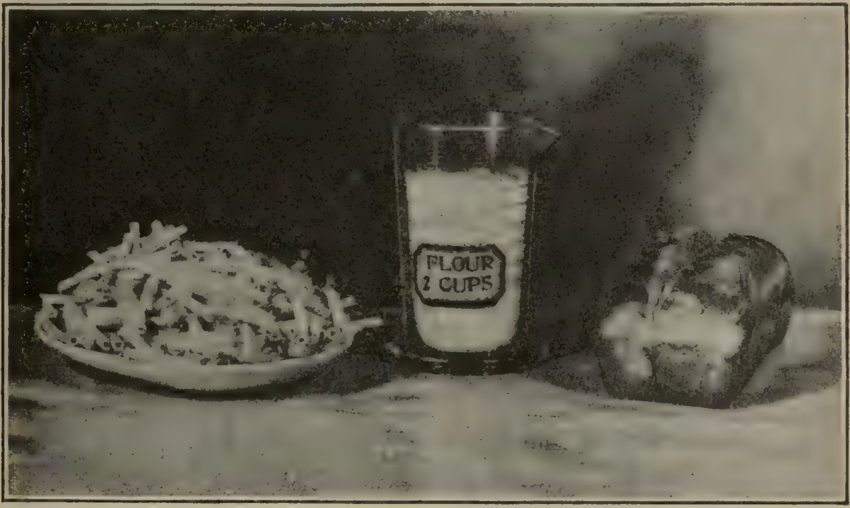

FIG. 1.—Flour, bread, and macaroni in quantities having the same general food value.

If the cereal were cooked in skim milk, which itself is rich in protein, this valuable material would be taken up by the cereal and the cooked dish would be by that much more nutritious than if cooked in water. A cupful of rice cooked slowly in a double boiler can be made to take up six cupfuls of skim milk, and the amount of tissue-building material the cooked dish contains is about four times as great as that of the rice alone.

In the same way the total food value of bread, cakes, etc., depends on all the materials from which they are made. If bread is mixed with water, its food value is about like that of the flour which goes into the loaf, for little besides water is added, and almost nothing is taken away in making the bread. Measured pound for pound, the bread has a lower food value than the flour, because it is

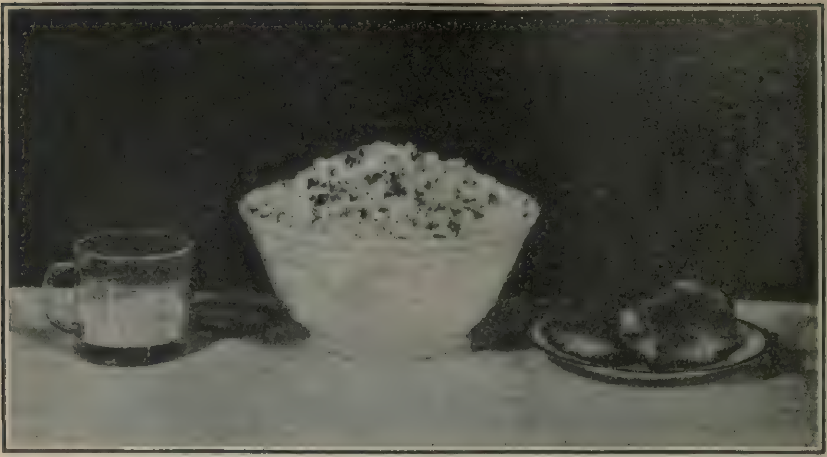

FIG. 2.—Corn meal, pop corn, and corn pone in amounts having the same general food value.

moister, owing to the water added in mixing the dough. If skim milk is used in the place of water in mixing bread, this makes the bread richer in body-building material. If a little sugar and fat are added, these make it more useful as body fuel. A cake made with two eggs provides more body-building material than one made with one egg, and if nuts and raisins are added, these add to the food value as well as to the flavor.

HOW MUCH CEREAL FOOD SHOULD BE USED?

Cereal food of one kind or another forms a large part of almost every wholesome and economical diet. As a general rule, the greater the part played by cereals the cheaper the diet. Up to a certain point one may cut down the quantity of meat, etc., eggs, butter, sugar, fruits, and vegetables used and substitute cereal foods, but there is a limit beyond which this can not be safely done. The sample day's ration for a family of father, mother, and three young children, discussed in a former bulletin of this series,[1] was planned to use cereals as freely as is considered wise. It contained about 4½ pounds of bread, or its equivalent in a variety of cereal foods, 2 quarts of milk, 1¼ pounds of medium-fat meat, 10 ounces of butter or other fat, ½ pound of sugar, and 4 or 5 pounds of fruits and vegetables. In this diet the cereal foods supply about one-half of the protein.

Ways of using the different cereal foods to advantage are discussed in the pages that follow.

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[1] U. S. Dept. Agr., Farmers' Bul. 808 (1917). How to Select Foods.—I. What the Body Needs.

BREAD.

In most households bread is the chief cereal food and the commonest kind is wheat bread raised with yeast.

Rye is also used in making yeast-raised bread. Corn is very commonly used in bread, but usually in kinds raised by some "quick" method rather than by yeast. Rice, oats, and the other cereals are not so much used in bread as in other dishes.

Because bread is often really "the staff of life," it is very important to have it good. People's ideas may differ as to exactly how bread should taste or how it should be made, but in this country all are agreed that yeast-raised bread should be light and spongy, with a crisp, tender, golden-brown crust, and that it should be nutty and sweet in flavor. Heavy, soggy bread, when it is swallowed, forms tough lumps which the digestive organs can not work upon properly, and, if eaten day after day, may do serious harm. Every housekeeper should try, therefore, to provide light, well-baked bread for her family.

Bread making often seems one of the most difficult of household tasks, with very uncertain results. There are many good rules for making bread, but whatever rule is followed the secret of success lies in following the directions exactly. This means not only using exactly the right amounts of materials and working the dough for the right time, but also letting the yeast grow in it and stretch it to the right extent.

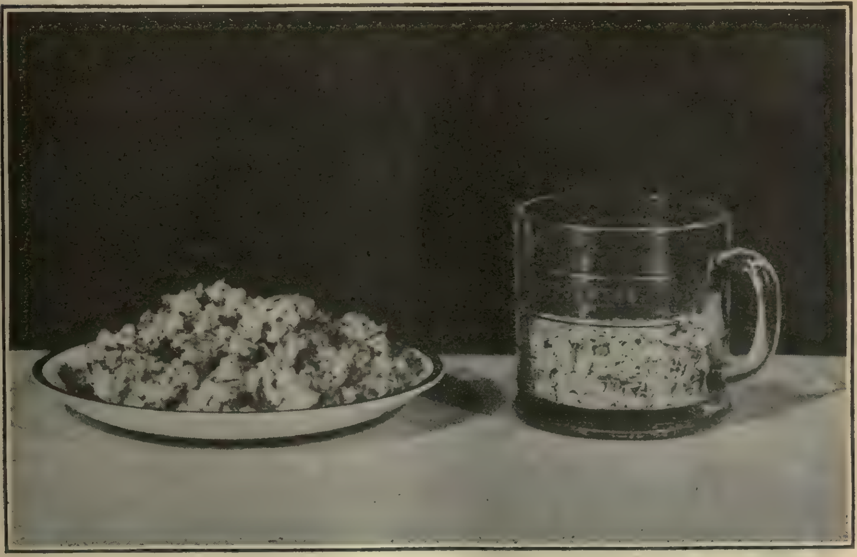

FIG. 3.—Half a cup of oatmeal before and after cooking.

Though there are many good recipes for making bread, a close examination shows that they differ more in minor details than in the main points. Some housekeepers prefer to start their dough at night, some in the morning; and they also vary in the number of times they knead it, but however it is made the proportions of material used are very similar. For almost every kind of simple yeast-raised bread as made in the United States from ordinary bread flour the following proportions are used for one loaf:

1 cup liquid (water, milk, skim or whole, whey, or a mixture of two or more of them).
1 level teaspoon salt.
1 level tablespoon sugar.
3 cups sifted flour (or a very little more or less).
Yeast (one-eighth to one-half cake compressed yeast, depending on the length of time the dough is to stand. Liquid and dry yeast may be used, but the exact amount can not be so easily stated).
If more loaves are to be baked at one time, multiply the quantities given above by the number of loaves desired.

The following paragraphs give brief directions for making bread according to the methods most commonly used in American households:

SHORT OR STRAIGHT-DOUGH PROCESS.

Boil the water or scald the milk. Put the sugar and salt (and fat, if used) into a mixing bowl. Pour the hot liquid over it and allow it to become lukewarm. Mix the yeast with a little of the lukewarm liquid and add it to the rest of the liquid. If convenient, set this aside in a warm place, not over 86° F., for one hour; if not convenient to set it aside, add the flour at once, putting in a little at a time and kneading until the dough is of such consistency that it

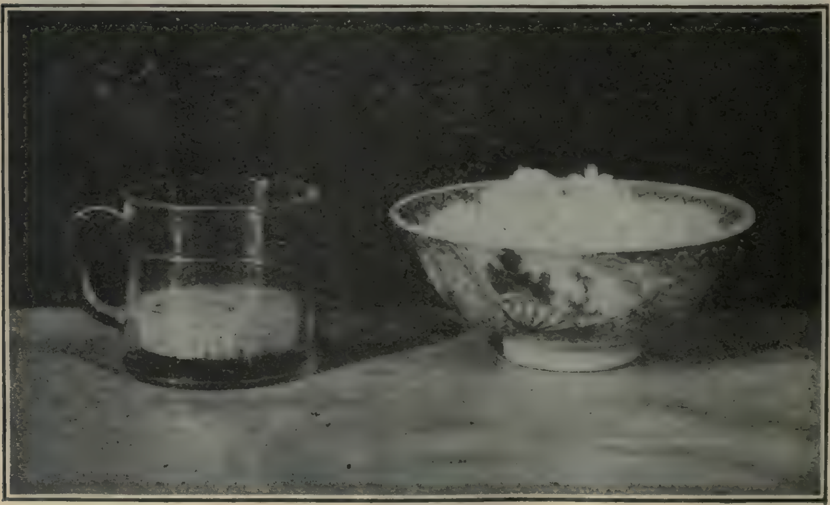

FIG. 4.—One-third of a cup of rice before and after cooking.

sticks neither to the bowl nor to the hands. This requires about 10 minutes. Cover, and allow to rise 1¾ hours at a temperature of 86°; it may be better to set it at a lower temperature, but the lower temperature the longer the time required for the rising. Cut down the dough from the sides of the bowl; grease the hands slightly. Knead a little and set aside to rise again for one hour. With a good bread flour, the dough would treble its bulk in each rising. With a soft wheat flour, it should not rise much beyond twice its volume. Divide into portions, mold, and place in greased pans. Allow to rise until a light touch will make a slight dent. Bake 50 minutes.

SHORT-SPONGE METHOD.

Bread can be made during the day by what is known as the "short-sponge" method. All the ingredients are the same as for the "short or straight-dough" process, but only half of the flour is added at first. When this mixture, which is called a "sponge," is so light that it will fall at the slightest touch, it is ready for the addition of the rest of the flour.

OVERNIGHT SPONGE METHOD.

Use the same proportions as for the short process, except in the case of the yeast, which should be one-eighth cake of compressed yeast or 2 tablespoonfuls of liquid yeast for each loaf. Use water rather than milk. In the evening mix the yeast with water, salt, and half of the flour, and beat thoroughly. Cover and place at a temperature of 65° to 70° F., or that of an ordinary room. In the morning add the sugar and the rest of the flour and proceed as in the case of the short process.

OVERNIGHT STRAIGHT-DOUGH METHOD.

Use the same ingredients as for the overnight sponge method, but put in all the ingredients at night.

If the following rules are observed, the bread is almost sure to be of good quality and to keep well:

(1) Keep everything clean, protect the flour from dust, and scald all liquid ingredients thoroughly.

(2) Keep the dough between 65° and 86° Fahrenheit and do not allow it to stand longer than necessary.

(3) See that the dough when placed in the oven has three times the bulk of the dough when first made. Dough made with 1 cupful of liquid will reach the top of a 1½-quart baking pan when it has tripled its bulk.

(4) Bake 45 to 60 minutes at about 400° Fahrenheit.

(5) Keep closely covered in a clean receptacle that is frequently scalded.

The principles of bread making are explained at length, and recipes for making different kinds of bread are given in another bulletin of this series.[1]

Some families are content with one kind of bread only, but others enjoy variety. There are many simple ways of obtaining it.

Yeast-raised bread can be made using graham, or the so-called whole-wheat flour instead of the usual bread flour. Or one may use two cups of wheat flour and one cup of cornmeal, oatmeal, peanut meal, soy-bean meal, or a corresponding amount of boiled rice or potato. Baking the dough in the form of biscuit or rolls instead of in a loaf changes not only its appearance but also its flavor, because in them there is more of the crisp brown crust in proportion to the crumb. Butter, sugar, raisins, nuts, and spice also give a variety which many families welcome now and then, as do caraway seed, aniseed, and poppy seed, used especially with rye bread.

There are many breads and biscuits raised with soda and sour milk or other mild acid, or with baking powder, which are often used instead of yeast-raised bread. If they are well made, they are perfectly wholesome. Unfortunately, in some parts of the country the biscuits are often made so large that the inside does not get thoroughly baked before the crust is done. Another rather common fault is using more soda than is needed. Too much soda not only injures the flavor, but may lessen, if not destroy, the growth-promoting substances in the bread.

Corn-meal breads raised by soda, baking powder, or eggs may also be freely used. Corn meal milled by modern processes does not make as moist bread as the old-fashioned type of meal, unless it is heated with water before the bread is mixed. If one understands this point, either kind of meal can be easily and satisfactorily used. Spoon breads made from corn meal or corn meal and rice are another kind, which varies the bread list. These are softer than ordinary bread, but not as soft as porridge or mush, and, unlike the latter, they have a distinct, well-browned crust.

Griddle cakes and pancakes are really a kind of thin bread cooked on a hot surface instead of in the oven, and in planning meals the wise housekeeper will think of them in this way. She will also remember that the butter and sirup often served with them yield valuable fuel, or energy, to the body.

LOW-PRICED QUICK BREADS.

A few recipes for low-priced quick breads are given below. In those raised by soda great care should be taken in measuring, as more soda than the acid of the sour milk can neutralize is believed to make the bread unwholesome. It is also important to have the bread thoroughly baked. The safest way is to make the biscuits or loaves small so that there may be a large proportion of browned crust.

Drop Biscuits.

2 cups white or whole-meal flour.
1½ teaspoons salt.
2 tablespoons lard or other fat.
1½ cups sour milk.
¾ level teaspoon soda.

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[1] U. S. Dept. Agr., Farmers' Bul. 807 (1917). Bread and Bread Making.

Sift the flour with the salt. Rub the lard or other fat into the flour by means of a fork or the fingers. Dissolve the soda in a little of the milk and add it, with the remainder of the milk, to the flour until a mixture is obtained that can be dropped from the end of a spoon. Bake on greased tins in a hot oven until brown.

Sour-Milk Corn Bread.

2 cups corn meal.
2 cups sour milk.
2 tablespoons butter.
2 tablespoons sugar, white or brown.
1½ teaspoons salt.
2 eggs.
1 teaspoon soda.
1 tablespoon cold water.

There are two ways of mixing this bread. By the first the meal, milk, salt, butter, and sugar are cooked in a double boiler for about 10 minutes. When the mixture is cool, the eggs are added well beaten and the soda dissolved in the water. By the other method all the dry ingredients, including the soda, are mixed together, and then the sour milk and eggs well beaten and the butter are added. If the second method is followed, the cold water is not needed. The bread should be baked in a shallow iron or granite pan for about 30 minutes.

Crisp Corn-Meal Cake.

1 cup milk.
½ cup white corn meal.
½ teaspoon salt.

Mix the ingredients and heat slowly until the boiling point is reached. It is not necessary to stir. Spread on a shallow buttered pan to a depth of about one-fourth of an inch. Bake in a moderate oven until crisp.

Spoon Corn Bread.

2 cups water.
1 cup milk.
1 cup white corn meal.
1 tablespoon butter.
2 eggs.
2 teaspoons salt.

Mix the water and the corn meal and bring slowly to the boiling point and cook 5 minutes. Add the eggs well beaten and the other ingredients. Beat thoroughly and bake in a well-greased pan for 25 minutes in a hot oven. Serve from the same dish with a spoon.

Crackers (also called biscuits in some regions) are really a kind of bread, baked very dry and usually in small and thin forms. Their food value, pound for pound, is very like that of twice-baked bread or rusks. It depends mainly on the flour or meal from which they are made, just as it does in bread, and, like bread, they are a wholesome and economical cereal food. Different flavorings and more or less shortening may be added in making them, and the crackers may be mixed and baked in different ways, so that the different kinds may not seem much alike. They do not usually vary as much in food value as they do in appearance. They are often convenient, because they give variety and because (on account of their dryness) they stay fresh a long time if kept in an air-tight box or wrapper. Crackers are rather bulky, and in buying them, as in buying breakfast cereals (see pp. 6 and 13), by the package, one should remember that it is not the size of the package but the weight of the crackers in it which shows how much food one is getting.

BREAKFAST CEREALS.

Next to their use in bread, cakes, etc., in this country, the most common way of using the cereals for food is in the form of the so-called breakfast foods. Sometimes, as in the case of rice, cracked wheat, and old-fashioned or "Scotch" oatmeal, the grains are simply husked and perhaps slightly crushed before being cooked. Sometimes meals are used, as in corn-meal mush. Sometimes the grains are ground rather finely and the outside parts sifted out, as in farina. In other cases, as in the rolled-oat preparations, the grain is cleaned, partially cooked by steam, and then run between rollers, which flatten it out. In still other preparations the partly cooked cereal is ground into fine, granular form, or pressed into thin flakes which are baked crisp, or the whole grains are cooked under pressure so that they puff or pop up somewhat as does popped corn, which may be used as a breakfast cereal as well as in other ways. Many of the devices used in preparing such breakfast foods are patented, and the products are often sold under proprietary names which may or may not suggest how the grains have been treated. What with all these methods of preparations, the list of varieties on the market is a long one, and the range of cost is great, especially when judged by the amount of food material actually supplied by a given quantity. All are wholesome foods.

As was shown on page 6, one can not judge the real cheapness or dearness of different kinds merely by the price paid for a package of a given size. Housekeepers who wish to be economical should note the net weight, which the law now requires to be marked on every package, and from this and the price reckon how much it costs per pound of material. They will find that, judged in this way, the simple flours and meals and the uncooked cereals (cracked wheat, coarse hominy or samp, unsteamed oatmeal, etc.) are usually the cheapest. When a preparation (steam-cooked oats, for example) can be bought either in package or in bulk, the cost of the package goods is usually, and quite justly, a little higher. Each housekeeper must decide for herself whether the greater convenience and attractiveness of the package goods is worth the difference in cost. The larger her family is, and the more good storage space she has, the greater will probably be the advantage of buying in bulk. If she decides to do this, she should be careful to get cereals which have been kept in clean, closed bins or bags and to keep them as carefully after they reach her home.

Plain, uncooked cereals (cracked wheat, coarse hominy or samp, unsteamed oatmeal, etc.) usually cost less than the partially cooked preparations and the partially cooked ones less than the ready-to-eat kinds, as seems reasonable since fuel and labor are used in the factory where they are made. More or less fuel and labor are also needed to prepare cereals in the home, and a wise housekeeper reckons with these in deciding which kind is most truly economical in her own case. The coarse, uncooked ones need longer cooking than the partially cooked kinds, while the ready-to-eat kinds need no cooking, or only enough to make them warm and crisp. In a household where a coal fire is kept in the range all day no more fuel and not much more work are required for the long, slow cooking of cracked wheat or "Scotch" oatmeal than for factory-cooked brands; or where a fireless cooker is used such cereals may be easily and cheaply cooked. Where gas, electricity, or liquid fuel is used, and it is a matter of economy to plan for as short a use of the stove as possible, it may be cheaper to use steam-cooked ones. In light housekeeping the convenience of the ready-to-eat preparations often more than compensates for their high cost. The pleasant variety given by the use of cereals manufactured in the more elaborate ways may seem to the housekeeper to be worth a few cents extra. It is worth remembering, however, that bread and milk, rusks and milk, and crackers and milk all have much the same food value as breakfast foods and milk, and often furnish a convenient and inexpensive variety.

There are several practical points to remember in cooking cereals. One is that there is more danger of not cooking them enough than of cooking them too much. Uncooked cereal preparations, like cracked wheat and coarse samp, need several hours' cooking, and are often improved by being left on the back of the stove or in the fireless cooker overnight. Cereals partially cooked at the factory, such as the rolled or fine granular preparations, should be cooked fully as long as the directions on the package suggest.

Flavoring is also an important part of cooking cereals. The flavor most commonly added is salt. Such added flavor is perhaps less necessary in some of the ready-to-eat kinds which have been browned at the factory and have thus gained the pleasant flavor which also appears in the crust of bread and cake or in toast, but in the plain boiled cereals or mushes the careful use of salt in cooking them may make all the difference between an appetizing and an unpalatable dish. A good general rule is 1 level teaspoonful of salt to each quart of water used in cooking the cereal.

Milk, cream, butter, sugar, or sirup are often added to breakfast cereals when they are eaten and make them more palatable to most persons. The materials also add to the food value of the whole dish.

Too much sugar or sirup should not be used, especially by children, as it may spoil the taste for other important foods. If cereals are properly salted most persons will not wish to use as much sugar as they otherwise would.

When in cooking cereal is placed in boiling water it must be constantly stirred to prevent its growing lumpy. This means unnecessary work, because ordinarily if the cereal is placed in cold water and heated slowly it needs no stirring at all; it will not lump. The best way to heat it slowly is in a double boiler, though with care it can be cooked directly on top of the stove. If so cooked stirring is necessary only when very large quantities are prepared and the upper part presses heavily on the lower part or when the cereal itself is very fine.

CAKES, PASTRIES, PUDDINGS, SAUCES, AND OTHER DISHES RICH IN CEREAL.

These dishes, varied as they seem, all have this in common: They are made by combining more or less flour, rice, corn meal, cornstarch, or other cereal preparation with materials from other food groups. In cakes, cookies, and puddings, sugar, egg, shortening, and various flavorings are added. In pastry a large proportion of fat is used, not to mention the fruit, custard, mincemeat, or other materials used in pie filling. In pudding the cereal—flour, bread or cake crumbs, cornstarch, corn meal, rice, or whatever it may be—is often mixed with milk as well as with sugar, spice, fruit, or whatever gives the distinctive flavor. Flour, cornstarch, and crumbs are also used in thickening sauces and soups and in various other made dishes.

It should be remembered that each of the materials that goes into such dishes adds to their food value; the less water they contain, the greater the food value of an ounce or a pound; and the more tissue-building protein and mineral salts in the different materials used in making them, the more of these important food substances there must be in the whole dish. A dish of rice pudding which is more than half water is not as nutritious as the same weight of cookies which contain only about one-seventh water, and sponge cake made with eggs is richer in protein than pound cake in which butter is used to give the desired texture.

When a housekeeper tries to reckon how much of the family food is furnished by articles from the cereal group, the dishes in which more or less of some cereal preparation is combined with things from other groups prove more troublesome than the simpler ones, such as bread or breakfast cereals. Though it is rather hard to know exactly how much flour, corn meal, cornstarch, or other cereal will be used in cooking on any one day, it is fairly easy to notice how much is used each week for perhaps a month, and from this to estimate the average daily amount. By noticing this she will not only learn how much nourishment her family is getting from the cereal foods used in cooking, but she may also discover ways of economizing either by preventing waste or by using more of the simple and relatively inexpensive foods made from cereals, such as desserts and other dishes in which the flavor of sugar, spices, or fruit, cheese, meat, etc., gives pleasant variety.

ECONOMIES WITH CEREAL FOODS.

Choosing the cereal preparations which provide the most actual nourishment for the money spent is, generally speaking, an economical way of using this group of foods. After they have been purchased it is equally important from the standpoint of thrift to use them so that nothing will be wasted because of poor cooking and flavoring or of providing more than can be used.

It is generally admitted that more bread goes to waste in the average American home than almost any other kind of food. This happens mainly because many housekeepers do not know what to do with stale bread. Good fresh bread has a springy quality which disappears as it ages, probably because the water in it gradually passes from the center of the loaf out through the crust, leaving the bread drier and more crumbly. Many persons think bread is better when it has dried out a little, say for 24 hours, but almost everyone agrees that really stale bread is too dry to eat with enjoyment. Bread that has been cut grows stale more quickly than the uncut loaf, and unless the housekeeper plans very carefully, she is likely to find her bread box full of hard, dry slices and ends of loaves which are of no use on the table. To avoid this waste she may do two things: (1) Treat the bread so it shall not be unappetizing and (2) use the stale bread in cooking.

Toasting is the most common method for making stale or partly stale bread attractive, but it is by no means the only one. If partly stale bread is put into a very hot oven for a few minutes it grows softer, probably because the heat tends to drive the water from the crust back into the crumb. Such warmed-over bread is not as soft and springy as fresh, but most persons find it very appetizing. A good plan, therefore, when bread has lost its freshness, is to cut off what will be needed at a meal and place the slices in a hot oven for a few minutes just before serving. In this way bread can be used on the table which would ordinarily be considered too stale.

"Twice-baked bread," which is cut bread placed in the warming oven, or in a pan on the back of the stove, and allowed to dry out very slowly until it is slightly brown and very crisp throughout, offers still another way of making stale bread attractive. If desired, this twice-baked bread may be crushed with a rolling-pin and used like the ready-to-eat breakfast cereals; in some localities this dish has long been known under the name of rusks. The little fried cubes of bread called "croutons," which are served with soup, may be made with odds and ends of bread. To save time, bread simply broken into small pieces may be fried either in deep fat or in a pan (sautéed) and used for the same purpose. Sometimes bread crumbs are fried in a pan for use in a similar way as a seasoning or sauce for meat. French cooks frequently put pieces of stale bread in soups just long enough before serving for them to soften; the well-known one called "crust in the pot" (croûte au pot) is simply a thin soup with bread in it.

There are many ways of using stale bread in cooking. Almost every good cookbook gives directions for preparing soft and dry crumbs for use in scalloped dishes, bread puddings, etc. The soft parts of the bread may be used in the place of flour or cornstarch for thickening soups, sauces, gravies, stewed tomatoes (either fresh or canned), etc. Bakers often use stale bread and dried, finely ground cake in place of part of the flour in making fancy breads, cakes, and cookies, and the housekeeper can often avoid waste by using them in this way in griddlecakes, cakes, cookies, etc.

The following recipes show how bread crumbs may be used instead of flour in various dishes. It will be noticed that nearly all the materials used in the soup are those that are often thrown away—skim milk, the outside leaves of lettuce, and stale bread.

VEGETABLE-SKIM-MILK SOUP.

1 quart skim milk.
1 slice stale bread.
2 ounces of the outer leaves of lettuce (6 large leaves).
A few celery tips, or
A thin slice onion.
Salt and pepper.

Chop the vegetables finely. A convenient way, particularly if the soup is being made in large quantities, is to use a food grinder and to put the bread through it with the vegetables to catch the juice. Cook the finely chopped vegetables and the bread in the milk in the double boiler for about 20 minutes. Season.

CHEESE FONDUE.

1⅓ cups soft, stale bread crumbs.
6 ounces cheese (1½ cups cheese grated fine or cut into small pieces).
4 eggs.
1 cup hot water or skim milk.
½ teaspoon salt.

Mix the water, bread crumbs, salt, and cheese; add the yolks thoroughly beaten; into this mixture cut and fold the whites of eggs beaten until stiff. Pour into a buttered baking dish and cook 30 minutes in a moderate oven. Serve at once.

Pancakes.

1 cup crumbs.
2¼ cups skim milk.
½ cup flour.
4 teaspoons baking powder.
1 teaspoon salt.
1 teaspoon sugar.
1 teaspoon melted fat.
1 egg.

Soak crumbs in milk for three-quarters of an hour. Then add other ingredients and cook on a hot griddle like ordinary pancakes. If sour milk is used, substitute ½ teaspoon soda for the 4 teaspoons baking powder.

Gingerbread.

1 cup molasses.
½ cup boiling water.
1⅓ cups fine bread crumbs.
⅔ cup flour.
1 teaspoon soda.
1½ teaspoons ginger.
½ teaspoon salt.
4 teaspoons melted lard, or other fat.

Add water to molasses and combine with the dry ingredients mixed together, then add butter and beat. Bake for about 25 minutes in a hot oven.

Indian Pudding Made with Crumbs.

1 cup fine crumbs (corn bread or wheat bread).
1 quart skim milk.
⅓ cup sugar.
¼ cup molasses.
2 tablespoons melted butter or other fat.
¼ teaspoon ginger.
¼ teaspoon cloves.
¼ teaspoon cinnamon.

Scald the crumbs in milk, add the other ingredients, and bake 1½ hours in a slow oven.

Stale crackers serve many of the same uses as stale bread. If they have lost their crispness, they, too, can usually be freshened by warming in the oven, and the fine crumbs may be used in the same way as dried bread crumbs.

The texture of stale cake and cookies is not so easily improved by heating, but they may be dried, crushed, and used like bread crumbs wherever their flavor and texture allow.

Remnants of cereal breakfast foods may often be utilized to make palatable dishes, to thicken soups or other foods, and in similar ways. For instance, small quantities of cooked cereal left over from a meal can be molded in cups and reheated for later use by setting the cups in boiling water. Another way to economize cereal mushes is to add hot water to any mush left over so as to make it very thin. It can then easily be added to a new supply. The practice of frying the left-overs of boiled hominy or of corn-meal mush is as old as the settlement of this country, and the nursery song about the "bag pudding the queen did make" from King Arthur's barley meal shows us that for centuries other cereal puddings have been treated in the same way. In so-called oatmeal oysters, left-over cereal is dipped in eggs and crumbs and fried. The use of left-over rice and other cereals in croquettes, puddings, and so on is too well known to need more than mention.

Cold cooked farina or similar cereal may be utilized in the following ways. The second recipe is less economical because of the use of egg and more milk.

FARINA PUDDING.

RECIPE NO. 1.

1 cup cold, cooked farina.
½ cup milk.
⅓ cup sugar.
½ cup seeded raisins.
⅛ teaspoon cinnamon.
A speck of ground cloves.

Bake until brown, or heat on top of the stove.

RECIPE NO. 2.

1 cup cold, cooked farina.
1 tablespoon cornstarch.
1 egg.
1 cup milk.
⅓ cup sugar.
½ cup seeded raisins.
⅛ teaspoon cinnamon.
A speck of ground cloves.

Bake in a medium oven until brown, or heat on top of the stove.

Dried figs or dates or stewed fruit may be substituted for the raisins in either of these puddings.

Boiled rice and pearl barley are often used in soup, and there is no reason why small quantities of coarse samp or any other cereal which will keep its shape fairly well should not be used up in the same way. Similarly, remnants of macaroni broken into small pieces may be used in the place of vermicelli or other special soup pastes. Such practices serve the double purpose of using material which would otherwise be wasted and of giving a little variety to a simple diet by inexpensive means.

In many places good, clean, whole wheat can be obtained quite as easily and cheaply as the common cereal preparations. It is possible to grind this in a mill like an ordinary coffee grinder so that it is as fine as old-fashioned cracked wheat, or even to a meal fine enough for bread making. When coarsely ground, such home-ground wheat makes an excellent breakfast cereal. Bread can be made entirely of the home-ground meal, but it is lighter and more delicate in flavor if half ordinary flour and half wheat meal are used. Grinding the grain, of course, takes time, and such home products are not recommended to take the place of others entirely. Occasionally, however, and especially when bran is needed in the diet (see p. 6), they may furnish a wholesome variety at low cost.

If other cereals cost less than wheat flour, the cost of bread may be lessened by using some of them in place of part of the flour. It has been found that good yeast-raised bread can be made with corn meal, rice, oatmeal, potatoes (see p. 21), etc., in place of at least one-third of the flour. The food value of such breads varies according to the food value of the material used, but the differences are not likely to be of importance when the diet is otherwise generous.

POTATOES AND SWEET POTATOES USED LIKE CEREALS.

These vegetables are so rich in starch and have so mild a flavor as compared with most vegetables that they are often used to supply fairly large amounts of body fuel without giving very decided taste to the diet. Raw potatoes contain more water than raw cereals, but when cooked they have much the same fuel value, pound for pound, as the cereals which have been cooked in water. A cupful of boiled potato would furnish the body with about as much energy as a cupful of boiled rice.

There are, however, some differences between the food value of these starchy vegetables and that of the cereals which must not be overlooked. They contain less fat and protein than most cereals, but, on the other hand, they furnish the body with a larger proportion of mineral substances. On this account they really belong in the food group with vegetables and fruits, rather than with the cereals. Nevertheless, because of the starch they contain and the ways in which they are combined in bills of fare with foods of more distinctive flavor they should be mentioned in connection with the cereals.

SUMMARY.

Cereals are mild-flavored, nutritious foods, which, in one form or another, make up a large part of most wholesome and inexpensive diets.

They are all rich in starch, which furnishes the body with fuel, or energy. They also furnish some tissue-building and body-regulating materials; these are more abundant in wheat, rye, and oats than in rice and corn.

The outer coating of the grain (called bran in wheat) contains valuable mineral matters and tiny quantities of little-known substances believed to be necessary to health. These are also found in milk, eggs, fresh fruits and vegetables. In some cases, especially where there is a tendency to constipation or where the other foods are not abundant, bread or breakfast cereals made with whole wheat, unpolished rice, and other cereal foods containing the outer parts of the grain are particularly valuable. Otherwise white flour or bread and polished rice are as valuable and wholesome as the whole-grain products.

The water added to cereal foods during cooking increases the bulk of the finished dish, but not its food value. One cupful of oatmeal may make four cupfuls of porridge, but the four would yield no more nourishment than was found in the original cupful of meal. In the same way, 3 cupfuls of flour has about the same food value as the pound loaf of bread into which it may be made.

Well-made bread of any kind is a wholesome and valuable food. Heavy, or underbaked, bread, if eaten day after day, may cause unpleasant digestive disturbance.

Waste of stale bread may be avoided (1) by freshening, toasting, or drying it to use instead of fresh bread, and (2) by using it in cooking in place of flour or starch.

Waste in breakfast foods and other cereal dishes may be avoided by serving only as much as is likely to be needed, and also by using any left-overs, reheating them, or in some way combining them with other food materials in cooking.

Breakfast cereals bought in bulk usually cost less than package goods, and raw cereals less than those which have been partly or entirely cooked at the factory.

In buying package goods, either breakfast cereals or crackers, one should judge the cost not merely by the size of the package but by the weight of the food in it.

Because cereals are relatively low in price and because most of them furnish some tissue-building materials as well as body fuel, it is good economy to use them freely and sometimes in the place of part of the more expensive foods.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE OF INTEREST IN CONNECTION WITH THIS BULLETIN.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Cereal Breakfast Foods. (Farmers' Bulletin 249.)
Use of Corn, Kafir, and Cowpeas in the Home. (Farmers' Bulletin 559.)
Corn Meal as a Food and Ways of Using It. (Farmers' Bulletin 565.)
School Lunches. (Farmers' Bulletin 712.)
Food for Young Children. (Farmers' Bulletin 717.)
Homemade Fireless Cookers and Their Use. (Farmers' Bulletin 771.)
Bread and Bread Making. (Farmers' Bulletin 807.)
How to Select Foods.—I. What the Body Needs. (Farmers' Bulletin 808.)
How to Select Foods.—Foods Rich in Protein. (Farmers' Bulletin 824.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Principles of Nutrition and Nutritive Value of Food. (Farmers' Bulletin 142.) Price, 5 cents.
Potatoes, Sweet Potatoes, and Other Starchy Roots as Food. (Department Bulletin 468.) Price, 5 cents.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

THE SMALL VEGETABLE GARDEN

SUGGESTIONS FOR UTILIZING LIMITED AREAS

FARMERS' BULLETIN 818

UNITED STATES DEPARTMENT OF AGRICULTURE

Prepared under the Direction of the Bureau of Plant Industry
WM. A. TAYLOR, Chief

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BY THE exercise of care and forethought in planning succession crops and rotations and by the utilization of every foot of available space it is possible to grow considerable quantities of vegetables on limited areas and so supplement the family food supply. The principal factors in accomplishing this are the use of seed boxes and hotbeds to give plants an early start in spring before seeds may be planted outdoors, the use of outside seed beds to carry plants for main-season crops while early crops are occupying the garden space, and the planting of late or succession crops as soon as earlier plants have been removed.

In order-that gardening may be carried on successfully in such an intensive way it is especially important that soil of good texture be available, and that it be well supplied with humus and plant food. It is essential also, as in all gardening, that sufficient moisture be present, that the garden be kept free of weeds, and that the soil be cultivated frequently and well.

In the following pages specific suggestions are made for planning an intensive garden enterprise, for preparing the soil and maintaining its fertility, and for planting and growing the crops.

THE SMALL VEGETABLE GARDEN.

CONTENTS.

	Page.		Page.
Essentials of gardening	3	Gardener's planting table	18
Planning the small garden	4	Cultivation	24
Choosing crops	8	Irrigation	25
Aids to earliness (hotbed, seed box, cold frame)	9	Protecting plants from diseases and pests	25
Tools	12	Cultural suggestions for the commoner vegetables	28
Preparing the soil	14	Vegetables for winter use	42
Planting vegetables in the open	16	Fruits in the small garden	44

ESSENTIALS OF GARDENING.

THE primary needs for successful vegetable gardening on a small scale are the same as those for gardening on a large scale. On limited plots, however, greater emphasis must be placed on intensive culture and carefully arranged rotations so that every available foot of space may be made to produce the maximum yield.

The essentials of all gardening are soil of suitable texture containing available plant food, water to dissolve the plant food so that the plant rootlets may make use of it, seeds or plants which will produce the desired crops, sunshine and warmth to bring about germination and plant development, and cultivation. Much also depends upon the gardener and the care he bestows on his enterprise.

Other factors—location and exposure—can not always receive much consideration in gardening small plots since there is ordinarily little room for choice. Such spaces are located usually in yards, or the choice of location is restricted in other ways by the necessity that the spaces be accessible to dwellings. When a possibility for the exercise of choice does exist, however, several considerations should be kept in mind by the gardener. It should be recognized that frost is less likely to injure vegetables planted on high ground than those planted in low places or valleys into which the heavier cold air commonly settles; that crops will mature more rapidly on land that has a sunny, southern exposure than on other plots; that the garden should be fairly level, but well drained; and that a warm, sandy loam will produce an earlier crop than a heavier soil that retains more water and less heat.

The soil is the storehouse of plant food and should, therefore, have a relatively open texture so that the rootlets of vegetables may extend themselves readily in their search for sustenance. A high proportion of humus or rotted vegetable material is desirable in the soil, since it produces an open texture, adds nitrogen, insures the presence of beneficial bacteria, aids in unlocking plant food from mineral particles, and increases the moisture-retaining properties of the soil.

About 50 per cent of ordinary earth is not soil at all, but consists of air and water. Water makes the soluble plant food that is present in the soil freely available, while the air in the soil makes possible bacterial development and facilitates chemical action, which makes additional plant food available.

IMPORTANCE OF A GOOD SEED BED.

The cultivation of crops is important because the stirring and loosening of the soil directly conserves moisture to some extent, kills weeds, which draw moisture and plant food at the expense of the crops, and incorporates air into the soil.

Too much emphasis can not be laid on the preparation of a good seed bed. A seed bed of fine tilth—made such by deep plowing, careful harrowing, and fining of the soil—is the foundation of good gardening. It is essential for the proper germination of seeds and growth of young plants. The soil must be friable and free from clods. A clod locks up plant food and prevents its utilization by the plant. Good soil and fine tilth furnish best conditions for root development. Upon the fine, hairy, fibrous, feeding roots, which are possible only in well-tilled soil, the plant depends for its stockiness and growth.

The careful gardener will regard his whole garden as a seed bed and will cultivate and fertilize it accordingly.

FERTILIZERS.

Fertilizers, the plant foods for the garden, should be carefully selected. Nitrogen, which stimulates leaf growth, is best supplied by turning under rich, well-rotted, or composted manure or rotting vegetable matter. Sheep manure and poultry droppings will hurry plants along more rapidly than most chemical fertilizers. These substances, as well as bone meal, also a valuable fertilizer, usually may be obtained from seed stores.

PLANNING THE SMALL GARDEN.

With a little forethought a comparatively small tract of land may be made to supply the average family with fresh vegetables throughout the growing season. Most owners of small gardens are content to raise a single crop on each plot of land at their disposal. It is quite possible, however, to grow two or three crops of some vegetables in one season, and if these are properly selected the home-grown produce should be both better and cheaper than any that can be purchased on the market.

Just what vegetables are to be grown depends, of course, upon the individual tastes of the family. In general the aim of the home gardener should be to raise vegetables in which freshness is an important quality. Peas, string beans, Lima beans, asparagus, and sweet corn, for example, lose much if they are not cooked almost immediately after they are picked. On the other hand, as good potatoes usually can be bought as can be grown. Moreover, potatoes occupy a large area in proportion to their yield and consume in a back yard or small garden valuable space which, in most cases, could be put to much more profitable use. This may be true also, in some cases, of corn, cucumbers, squashes, and melons.

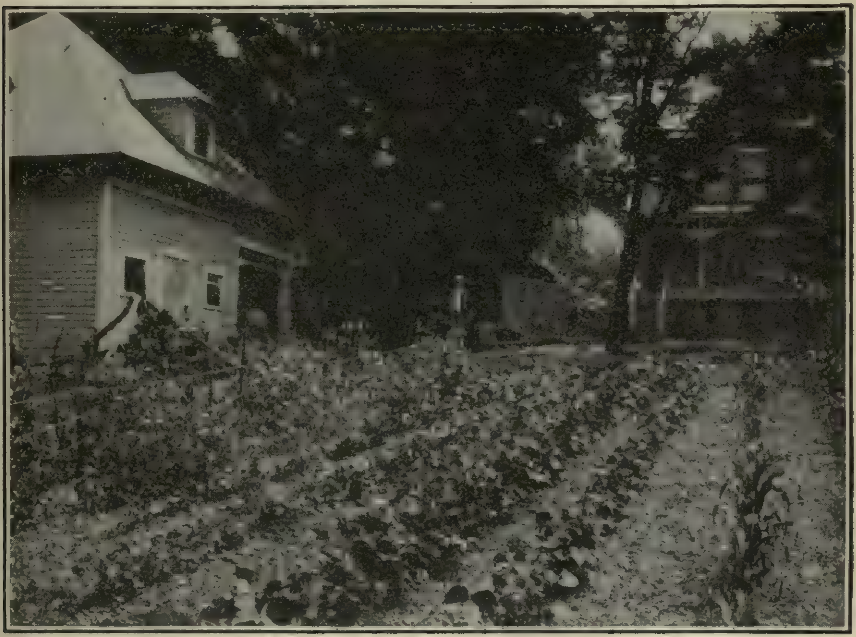

Fig. 1.—A back-yard vegetable garden which gives evidence of having received the care and attention that are essential to success in small-scale gardening.

It will pay the home gardener to grow certain specialties of which he may be fond, and which may be troublesome or expensive to purchase. Okra is an example of this class, and little beds of parsley, chives, or other herbs take up very little room and provide the housewife with additions for her table, which are most welcome if they can be picked at the right moment without trouble.

THE GARDEN DIAGRAM.

If the small garden plot, however, is to be made to bring the maximum returns in economy and pleasure to the owner, every available foot of it must be made to work continuously. This can be accomplished only by careful planning, and it is recommended, therefore, that a complete lay-out for the garden be drawn up in advance. A typical plan of this character is shown in figure 1. This plan, of course, will be of use chiefly as an example, and in most cases a different arrangement will be necessary to meet the conditions surrounding individual garden spaces. On the plan the gardener may indicate the approximate date when each of his projected crops is to be planted. No more space should be allotted to each than is needed to furnish a sufficient quantity of the vegetable for family consumption or for other known needs. In many cases, also, space should be left between the rows for the interplanting of later crops and for easy cultivation. Plants which make a high growth and cause heavy shade should not be located where they will interfere with sun-loving small plants. It is well also to separate perennials, such as rhubarb and asparagus, which are not cultivated, from plants which must be tilled.

THE DIAGRAM AS A RECORD.

If a garden is planned in this way and the scheme carried out, the plan should be kept for use the following year, with notes of the success or failure of the different items in it. For example, if too much or too little of any vegetable was grown, this fact should be recorded. It is not desirable, however, to follow too closely the same plan in succeeding years. The same kind of vegetables should not be grown twice, if this can be avoided, in the same part of the garden. The danger of attack by diseases and insects is heightened when vegetables of the same kind follow each other repeatedly in a given space, such as a row or bed. If a radically different kind of plant is grown in a space, on the other hand, disease spores and insects, though present in the soil, probably will not attack the second crop.

In making a diagram of the garden it is well to use a tough paper, such as heavy wrapping paper, which will stand repeated handling and use out of doors. A fairly large scale should be adopted, so that full notes can be kept in the spaces representing rows. If the garden is fairly large or abnormally long, the diagram may be made in separate sections for the sake of convenience.

A BACK-YARD GARDEN.

The garden shown in the diagram (fig. 2) was a city back yard 25 by 70 feet in dimensions near New York City. It happened

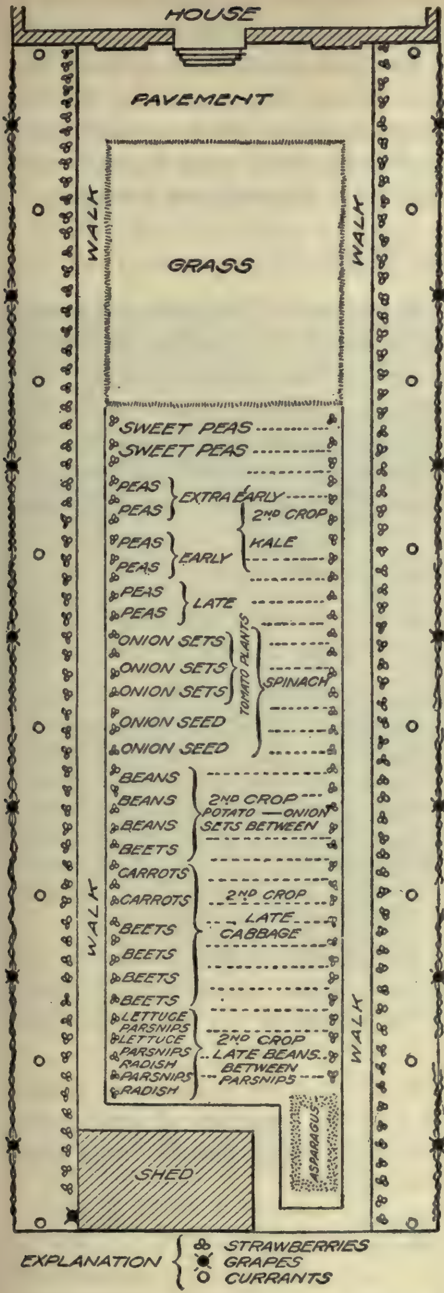

FIG. 2.—A typical back-yard garden plan, showing a possible arrangement for permanent and annual plants.

to be bounded on two sides by a board fence, and advantage was taken of this fact to plant and train grape vines. Strawberry plants were set alongside the flagstone walks and currant bushes between the walks and the fence. In the space between the bushes and the strawberries low-growing vegetables, such as bush beans, peppers, eggplants, and the like, were set out. In a space about 12 feet wide between the walks low-growing, quick-maturing varieties of early vegetables were planted in such a way that later-maturing varieties could be put out at proper intervals between them. The early plantings consisted of radishes, early beets, lettuce, carrots, and a few parsnips. The beets gave way later to a few late cabbage plants. The sunniest portion of the yard was turned over to tomatoes, of which there were about a dozen plants trained to a single stem and set about 18 inches apart in each direction. Early and late peas were put out in the least sunny portions of the yard. Later, in the fall, spinach, kale, and potato-onion sets were planted in order to provide a supply of green succulents for the winter and early spring.

IMPORTANCE OF SUNLIGHT.

In making the garden plan the gardener should recognize that no amount of fertilizer, watering, and cultivation will make up for the absence of sunlight in a garden. Careful consideration should be given to how many hours a day any part of the yard is in shadow from buildings, fences, or trees. If a successful garden is to be maintained, the greater portion of the plot must have at least five hours of sunlight a day. As a rule foliage crops, such as lettuce, spinach, and kale, do fairly well in partial shade, but even these need sunshine two or three hours a day. Plants which must ripen fruits, such as tomatoes and eggplant, should have the sunniest locations.

CHOOSING CROPS.

Vegetable seed should be ordered in advance of the time for planting in the open, so that they will be on hand for planting in flats or frames and also for use outdoors as soon as the weather and the condition of the soil make planting possible. Before ordering seed it is a good idea to look over the garden plot, decide on the best location for each vegetable, and determine how much seed will be required for the space available for each variety. The garden plan may then be drawn.

SEED FOR A FAMILY OF FOUR.

The following are the approximate quantities of seed that should be purchased for a garden which is to supply vegetables for successive plantings throughout the season for a family of four:

Beans, snap	1 pint.	Parsnips	½ ounce.
Beans, pole Lima	½ pint.	Salsify	1 ounce.
Beans, bush Lima	½ pint.	Squash, summer	½ ounce.
Cabbage, early	½ ounce.	Squash, Hubbard type	½ ounce.
Carrot	1 ounce.	Cauliflower	1 packet.
Celery	1 ounce.	Eggplant	1 packet.
Cucumber	½ ounce.	Parsley	1 packet.
Kale, or Swiss chard	½ ounce.		

For most of the vegetables listed the plantings may consist of the entire quantities mentioned. Relatively small quantities of cauliflower, eggplant, and parsley will be sufficient for most families, however.

The following vegetables undoubtedly will be planted in larger amounts than those just mentioned, and the amounts of seed given will be a guide for ordinary requirements. Some families may need more of the various vegetables and others less:

Beet	2 ounces.	Radish	1 ounce.
Cabbage, late	½ ounce.	Spinach	¼ pound in spring and ½ pound in fall
Corn, sweet	1 pint.	Tomatoes, late	¼ ounce.
Lettuce	½ ounce.	Turnips	1 ounce.
Muskmelon	1 ounce.		
Onion sets	2 quarts.		
Peas, garden	2 to 4 quarts.		

The entire supply of seeds of string bean, bush Lima bean, sweet corn, lettuce, peas, and radish should not be planted at one time, but successive plantings two to three weeks apart should be made so that a fresh supply of the vegetables may be had throughout the season.

Of early Irish potatoes 1 peck to ½ bushel will be required, and of late potatoes ½ bushel to 1 bushel, or more, depending upon the amount of ground available for this purpose. If abundant space is available, it may be well to grow enough Irish potatoes to last throughout the winter.

If the family wishes to raise vegetables to supply current needs and also to supply a surplus for canning, the amounts indicated above should be increased considerably.[1]

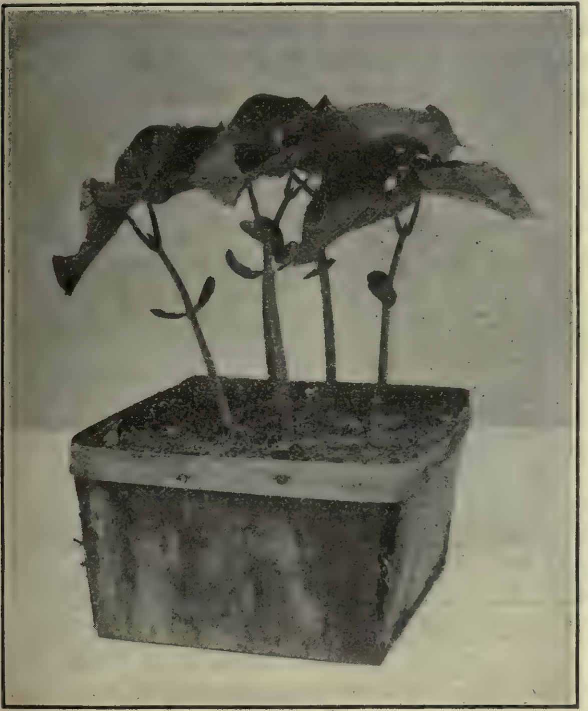

FIG. 3.—A hill of beans started in a berry box in the house long before the seeds may be planted in the open garden.

AIDS TO EARLINESS.

The hotbed, the "flat" or seed box, and the cold frame are the gardener's greatest aids in raising early crops. The hotbed and the flat enable him to plant seed and produce seedlings long before most of the seeds may be planted out of doors and before those which have been planted in the plot have begun to germinate. The cold frame enables him to get the seedlings produced in the hotbed gradually accustomed to outdoor conditions and to raise these into strong, sturdy planting stock by the time the garden is ready for them. Resetting from a hotbed into a cold frame, or from one flat into another, or into pots, gives most plants a better root system and makes them stockier and more valuable for transplanting into the open ground. Besides being used in hardening plants that have been started in the hotbed, the cold frame is utilized in mild climates instead of a hotbed for starting plants before seeds can be planted safely in the open. In the extreme South the cold frame is much more extensively used than the hotbed, but each has its place in garden economy.

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[1] The home gardener should find useful Farmers' Bulletins 359, Canning Vegetables in the Home; 521, Canning Tomatoes, Home and Club Work; 255, Home Vegetable Garden; and 647, Home Garden in the South. The latter is designed particularly for use in the warmer climates, but contains many suggestions that can be adapted readily by home gardeners in the North. The Department of Agriculture will supply these bulletins free on application as long as its stock for free distribution lasts.

Still another method of giving plants an early start is used extensively for beans, cucumbers, melons, sweet corn, and other warmth-loving plants. This consists in planting enough seeds for a "hill" in berry boxes filled with soil. (Fig. 3.) The boxes are kept in the house or in greenhouses until the garden soil becomes warm, by which time the plants should have reached a considerable degree of development. The bottoms of the boxes are then cut away and the remaining frame is sunk with the plants in their permanent location in the garden.

STARTING EARLY VEGETABLES IN THE HOUSE.

The flat or seed box (fig. 4) which is kept in the house is perhaps the most practical device for use by the home gardener for starting early vegetables. By its use earlier crops of tomatoes, cabbage, cauliflower, Brussels sprouts, peppers, eggplant, and lettuce can be had with little outlay for equipment. Early potatoes sometimes are forced in the same way. Seeds so planted germinate and are ready for transplanting by the time it is safe to sow the same kind of seed in the open ground. When danger of frost is over and the soil is dry enough to work, therefore, the early garden may be started with seedlings well above the surface. Transplanting, if properly done, instead of injuring seems to help such plants to develop a strong root system.

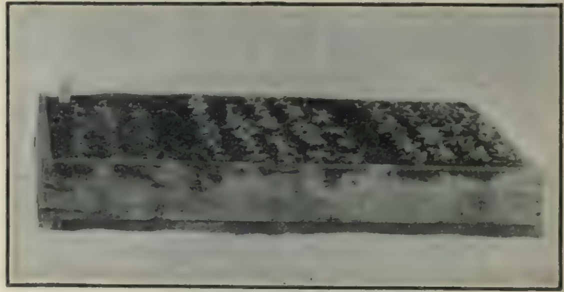

FIG. 4.—Flat or seed box for use in starting plants in the house.

HOW TO MAKE AND USE A SEED BOX.

Any sort of wooden box filled with good soil answers the purpose, but the following specific suggestions for a box of convenient size may be useful. Construct a box 3 to 4 inches deep, 12 to 14 inches wide, and 20 to 24 inches long. A layer of about 1 inch of gravel or cinders should be placed in the bottom of the box. It should then be filled nearly full with rich garden soil or soil enriched with decayed leaves or manure. The rich soil beneath the family woodpile or around decaying logs is splendid for this purpose. The soil should be pressed down firmly with a small piece of board and rows made one-fourth to one-half inch deep and 2 inches apart crosswise of the box. The seed should be distributed 8 or 10 to the inch in the rows and be covered. The soil should be watered and the box set in a warm place in the light. The best location is just inside a sunny window. Water enough must be given from time to time to cause the seeds to germinate and grow thriftily, but not enough to leak through the box. If a piece of glass is used to cover the box, it will hold the moisture in the soil and hasten the germination of the seeds.

When the plants are from an inch to an inch and a half high they should be thinned to 1 or 2 inches apart in the row, so as to give them space enough to make a strong stocky growth. If it is desired to keep the plants which are thinned out, they may be set 2 inches apart each way in boxes similar to the seed box. When the weather becomes mild the box of plants should be set out of doors part of the time so that the plants will " harden off " in preparation for transplanting to the garden later. A good watering should be given just before the plants are taken out of the box for transplanting, so that a large ball of earth will stick to the roots of each one.

THE HOTBED.

Locate the hotbed in some sheltered but not shaded spot which has a southern exposure. The most convenient size is a box-like structure 6 feet wide and any multiple of 3 feet long, so that standard 3 by 6 foot hotbed sash may be used. The frame should be 12 inches high in the back and 8 inches in the front. This slope is for the purpose of securing a better angle for the sun's rays and should be faced toward the south.

The hotbed not only must collect any heat it can from the sun, but also must generate heat of its own from fermentation in fresh manure. Fresh horse manure, free from stable litter, is best for generating heat.

If the hotbed is to be an annual affair, make an excavation 18 inches to 2 feet deep, about 2 feet greater in length and width than the frame carrying the sash. Line the excavation with plank or with a brick or concrete wall. A drain to carry off surplus water is essential. This may consist of either tile or pipe extending to a low portion of the garden or a trench partially filled with coarse stones covered with a layer of hay or sod and then filled level with soil.

After a sufficient amount of fresh horse manure has been accumulated fill the hotbed pit, and while it is being filled tramp the manure as firmly and as evenly as possible. When the ground level is reached, place the frame in position and bank the sides and ends with manure. Place about 3 inches of good garden loam on top of the manure inside the frame and cover it with the sash. After the heat has reached its maximum and has subsided to between 80° and 90° F. it will be safe to plant the seeds. Select the plumpest, freshest seeds obtainable. Use standard varieties, and get them from reliable seed houses.

Keep the bed partially dark until the seeds germinate.

After germination, however, the plants will need all the light possible, exclusive of the direct rays of the sun, to keep them growing rapidly. This is a crisis in plant life, and ventilating and watering with great care are of prime importance. Too close planting and too much heat and water cause the plants to become spindling. Water the plants on clear days, in the morning, and ventilate immediately to dry the foliage and to prevent mildew.

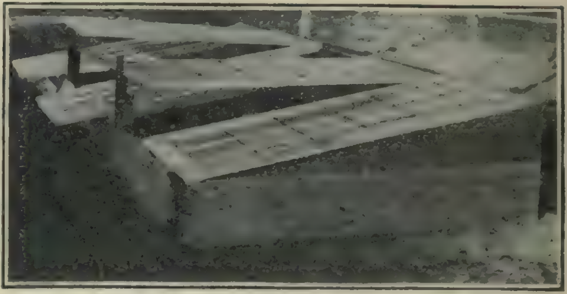

FIG. 5.—Cold frame open for ventilating plants.

THE COLD FRAME.

The cold frame (fig. 5), so useful in hardening plants started in the hotbed and for starting plants in mild climates, is constructed in much the same way as the hotbed, except that no manure is used, and the frame may be covered either with glass sash or with canvas. A cold frame may be built on the surface of the ground, but a more permanent structure suitable for holding plants over winter will require a pit 18 to 24 inches deep. The cold frame should be filled with a good potting soil. The plants should have more ventilation in the cold frame, but should not receive so much water. It is best to keep the soil rather dry.

In transplanting, remember that plants usually thrive better if transplanted into ground that has been freshly cultivated. Transplanting to the open field is best done in cool, cloudy weather and in the afternoon. This prevents the sun's rays from causing the plant to lose too much moisture through evaporation. In transplanting the gardener will find a child's express wagon an excellent trolley tray for bedding out his seedlings.

TOOLS.

The necessary tools for preparing and caring for the small garden are few. A spade or garden fork for digging, a hoe, a steel-tooth rake, a trowel, and a dibble or pointed stick complete the list of essentials. The gardener will find it convenient, however, to possess some additional implements. (Fig. 6.) If tree roots underlie any portion of the garden plot and must be cut away, a hatchet, ax, or mattock will be a real necessity. If the soil of the plot has become compacted, as where walks have existed, a pick may be needed for digging. Perhaps in such cases it will be most economical to fill both cutting and digging needs by purchasing a pick-ax which has a pick point at one end of the head and a cutting blade at the other. Apparatus for watering plants also should be included. This may be a watering pot of generous proportions or, where running water is available, a

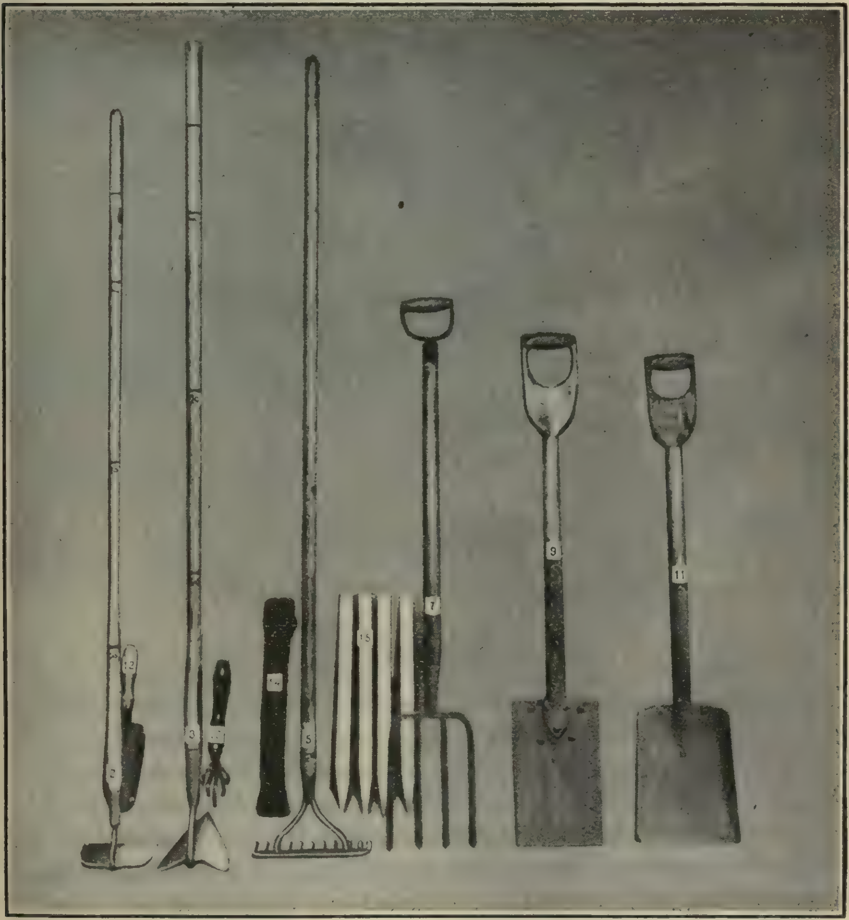

FIG. 6.—A set of garden tools, including the essential implements and a few others. (2) Hoe, (3) heart-shaped furrow hoe, (5) steel-tooth rake, (7) fork, (9) spade, (11) shovel, (12) trowel, (13) scratch weeder, (14) line, (15) stakes. Note that the handles of some of the longer implements are marked off in feet and half feet for convenience in measuring.

hose. In order that rows may be made straight and uniform a substantial line or cord should be provided.

A most convenient implement for use in the home garden, especially where the plot is fairly large, is a hand cultivator or wheel hoe. (Fig. 7.) This implement is a miniature cultivator or plow, with adjustable blades, mounted on a wheel or wheels, and is pushed along by hand. Attachments make possible either the turning of small furrows, the stirring of the soil, or the removal of weeds. Much time and labor may be saved by such a device.

Among the other implements which may be useful in the home garden but which are not essential are planting and cultivating hoes of special shapes, a combination hoe and rake, a wheelbarrow, a shovel, hand weeding tools, and other small implements for special uses (fig. 8).

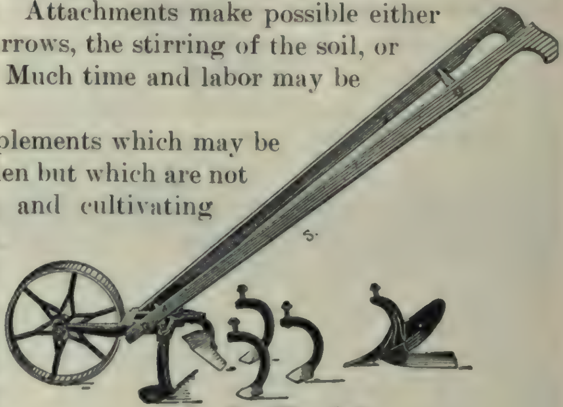

Fig. 7.—Wheel hoe.

PREPARING THE SOIL.

A simple test to determine when garden soil is ready for plowing or working is to take a handful of earth from the surface and close the fingers tightly on it. If the earth compacted in this way is dry enough for cultivation, it will fall apart when the hand is opened. This test is applicable only to comparatively heavy soils, but it is these which receive the most injury if they are worked when wet. On such soils overzealous gardeners not only waste their time but frequently do actual damage by attempting to work them too early.

BREAKING.

The kind of preparation that must be given to the small garden and the amount of work that will be required will depend largely, of course, on the condition of the plot and the use to which it has been put. If the ground selected for the garden has been firmed by much tramping, as is often the case in back yards, it can not be got into proper condition without the expenditure of considerable labor. When plowing with a team can be practiced that is the best method for giving the ground its initial breaking. The surface, of course, should be harrowed as soon as possible after plowing.

If the plot can not be plowed, the gardener must resort to the use of a garden fork or spade or, in the case of very hard spots, a mattock. The soil should be well loosened to the depth of the spade or fork. If heavy clay is encountered at this depth, it should not be turned up to the surface, but the slices of soil should be kept in their normal position. As soon as each spade or fork full of earth is loosened, it should be broken up by blows with the back of the implement. Later the freshly dug surface should be fined and smoothed with a steel-tooth rake. It is not sufficient that the surface be made fine; the soil should be well pulverized to the depth of the digging. Any sod or plant growth on the garden plot should be turned under to rot and form humus. In turning under sod with a spade or fork it is well to reverse each segment so that foliage will be down and roots up.

The first digging of a plot of ground which has not before been cultivated is likely to be a laborious task, and may even take away the enthusiasm of the would-be gardener. After this portion of the work is done, however, the fining of the soil, planting, and cultivation are not arduous. It may be well in many cases for the gardener to employ some one to break his ground, whether this be done with plow, spade, or fork.

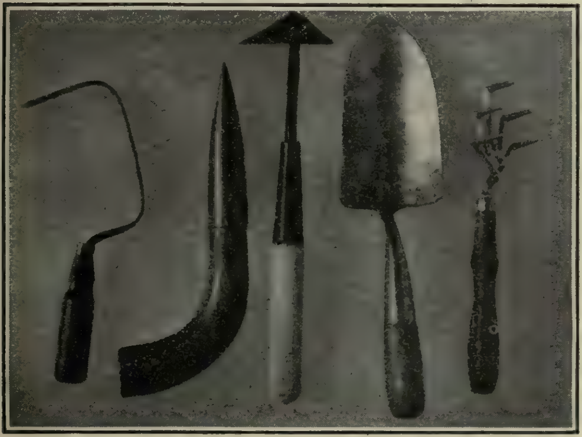

FIG. 8.—Small hand tools for the garden. From left to right they are: Hand weeder, dibble, onion hoe, trowel, and scratch or claw weeder.

IMPROVING SOIL TEXTURE.

It is desirable that the soil of the garden be as open and light as possible. Where a natural loam exists in the plot good texture can be given by digging and cultivating. Where the soil is heavy, containing much clay, however, other steps are necessary. If clean sand is available this may be mixed with the soil. Well-sifted coal ashes which, unlike wood ashes, have no fertilizing value, are useful in lightening the soil. Care should be taken that no coarse cinders or pieces of partly burned coal are added to the soil with the ashes.

Lime added to the soil also will tend to lighten it and will, at the same time, correct acidity. A thin coat of air-slaked lime should be spread on the ground and worked in well. Lime is not a plant food, but its function in gardening is important none the less. By correcting acidity it makes possible the development of countless soil bacteria which aid in unlocking plant food from the mineral particles of the soil and in making these substances available for the plants. In acid soils these helpful organisms do not thrive, and in their absence vegetables do not grow at their best.

FERTILIZERS.

After the soil has been got into good mechanical condition, it usually is desirable to apply some form of fertilizer. Barnyard or stable manure, which furnishes both plant food and humus, undoubtedly is the best, and applications of from 20 to 30 tons to the acre are satisfactory. This is roughly equivalent to from 400 to 600 pounds, or several wheelbarrow loads, for each plot 20 by 20 feet. The manure should be distributed evenly over the surface, and later worked in with a hoe and rake.

Frequently it is advisable also to apply commercial fertilizer. An application of 1,000 to 1,500 pounds to the acre, or 10 to 15 pounds per plot 20 feet square, usually is sufficient. In order to supply potash, if this is needed, unleached wood ashes may be distributed over the garden at the rate of 1,000 pounds to the acre, or 10 pounds to each plot 20 feet square. Wet or leached ashes have less fertilizer value. Double the quantity of these should be used. In order to start the plants in the spring, applications of 100 pounds to the acre of nitrate of soda, or 1 pound to each 20-foot square, may be used. By far the best way to use nitrate of soda in the small garden, however, is to dissolve a teaspoonful of the chemical in a gallon of water and use the solution for watering young plants. It is important to remember that no form of commercial fertilizer will yield good results unless the soil is well supplied with humus.

Reference already has been made to the use of prepared sheep manure as a fertilizer. When this plant food can be obtained at a reasonable price, it is perhaps the safest concentrated fertilizer for use by the home gardener. It will not pay to broadcast prepared sheep manure. Small quantities should be applied under the drill when the seeds are planted or the plants set out. Later applications may be worked in with a trowel around the plants.

PLANTING VEGETABLES IN THE OPEN.

WHEN TO PLANT.

Vegetables may be divided into two classes—"cold temperature" and "warm temperature" vegetables. When peach and plum trees are in blossom, or, where these trees do not occur, when silver maples put forth leaves, or catkins appear on willows and poplars, it is time to sow in the open ground the seeds of lettuce, spinach, kale, endive, radish, parsley, beets, turnips, cabbage, cauliflower, Brussels sprouts, carrots, round-seeded peas, and onions. The wrinkled peas should not be planted until later, as they are more likely to rot in cool ground than are the smooth varieties. When the apple trees bloom, or when the dogwood and white oak buds unfold, it is time to plant the heat-loving vegetables such as cucumbers, beans, sweet corn, okra, pumpkin, and squash. This is an old approximation for planting dates, but has been found in most cases to be satisfactory.

Planting times may be fixed in still another way on the basis of the occurrence of frost. Frost ordinarily will kill tender growths of vegetables, but young plants of a few kinds will survive light frosts. Among the latter, which may be called Group I, are cabbage, lettuce, Irish potatoes, early peas (smooth seeded), onion seeds and sets, parsnips, salsify, beets, radishes, and such salad plants as kale, spinach, and mustard.

A "second early" group of vegetables, which may be called Group II, may be planted as soon as danger of frost is over. In this group are included lettuce plants and seeds, radishes, wrinkled peas, carrots, and early sweet corn.

A week or 10 days after the seeds and plants of Group II are placed in the ground, string beans and late sweet corn, constituting Group III, may be planted.

A group of plants, which may be called Group IV, should be planted only after the ground has begun to warm up. In this group are cucumbers, melons, squashes, pumpkins, Lima beans, and tomato, eggplant, and pepper plants.

Detailed suggestions for planting are given in a table on pages 18 and 19.

DEPTHS OF PLANTING.

No general rule can be given with regard to the depth for planting seeds, since different varieties of vegetables and different soils necessitate different practices. The smaller the seeds, usually, the shallower the planting should be. In heavy clay or moist soils the covering should be lighter than in sandy or dry soils.

GARDENER'S PLANTING TABLE.

Quantity of seeds or number of plants required for a row 100 feet in length, with distances to plant, times for planting, and period required for production of crop.

[Brackets indicate that a late or second crop may be planted the same season.]

Kind of vegetable.	Seeds or plants required for 100 feet of row.	Distance for plants to stand—			Depth of planting.	Time of planting in open ground.		Ready for use after planting.
		Rows apart.		Plants apart in rows.		South.	North.	
		Horse cultivation.	Hand cultivation.					
Artichoke, globe	½ ounce	3 to 4 ft	2 to 3 ft	2 to 3 ft	1 to 2 in	Spring	Spring	15 months.
Artichoke, Jerusalem	2 qts. tubers	3 to 4 ft	1 to 2 ft	1 to 2 ft	2 to 3 in	Spring	Spring	6 to 8 months.
Asparagus, seed	1 ounce	30 to 36 in	1 to 2 ft	3 to 5 in	1 to 2 in	Autumn or early spring	Early spring	3 to 4 years.
Asparagus, plants	60 to 80 plants	3 to 5 ft	12 to 24 in	15 to 20 in	3 to 5 in	Autumn or early spring	Early spring	1 to 3 years.
Beans, bush	1 pint	30 to 36 in	18 to 24 in	5 or 8 to ft	½ to 2 in	February to April. [August to September.]	April to July	40 to 65 days.
Beans, pole	½ pint	3 to 4 ft	3 to 4 ft	3 to 4 ft	1 to 2 in	Late spring	May and June	50 to 80 days.
Beets	2 ounces	24 to 36 in	12 to 18 in	5 or 6 to ft	1 to 2 in	February to April. [August to September.]	April to August	60 to 80 days.
Brussels sprouts	¼ ounce	30 to 36 in	24 to 30 in	16 to 24 in	½ in	January to July	May and June	90 to 120 days.
Cabbage, early	¼ ounce	30 to 36 in	24 to 30 in	12 to 18 in	½ in	October to December	March and April. (Start in hotbed during February.)	90 to 130 days.
Cabbage, late	¼ ounce	30 to 40 in	24 to 36 in	16 to 24 in	½ in	June and July	May and June	90 to 130 days.
Cardoon	½ ounce	3 ft	2 ft	12 to 18 in	1 to 2 in	Early spring	April and May	5 to 6 months.
Carrot	1 ounce	30 to 36 in	18 to 24 in	6 or 7 to ft	½ in	March and April. [September.]	April to June	75 to 110 days.
Cauliflower	¼ ounce	30 to 36 in	24 to 30 in	14 to 18 in	½ in	January and February. [June.]	April to June. (Start in hotbed during February or March.)	100 to 130 days.
Celeriac	¼ ounce	30 to 36 in	18 to 24 in	4 or 5 to ft	⅛ in	Late spring	May and June. (Start in cold frame during April.)	100 to 150 days.
Celery	¼ ounce	3 to 6 ft	18 to 36 in	4 to 8 in	⅛ in	August to October	May and June. (Start in hotbed or cold frame during March or April.)	120 to 150 days.
Chervil	1 ounce	30 to 36 in	18 to 24 in	3 or 4 to ft	1 in	Autumn	Autumn	1 year.
Chicory	¼ ounce	30 to 36 in	18 to 24 in	4 or 5 to ft	½ in	March and April	May and June	5 to 6 months.
Citron	1 ounce	8 to 10 ft	8 to 10 ft	8 to 10 ft	1 to 2 in	March and April	May and June	100 to 130 days.
Collards	¼ ounce	30 to 36 in	24 to 30 in	14 to 18 in	½ in	May and June	Late spring	100 to 120 days.
Corn salad	2 ounces	30 in	12 to 18 in	5 or 6 to ft	½ to 1 in	January and February. [September and October.]	March to September	60 days.
Corn, sweet	¼ pint	36 to 42 in	30 to 36 in	30 to 36 in	1 to 2 in	February to April	May to July	60 to 100 days.
Cress, upland	½ ounce	30 in	12 to 18 in	4 or 5 to ft	½ to 1 in	January and February. [Autumn.]	March to May. [September]	30 to 40 days.

Cress, water	½ ounce	Broadcast			On surface	Early spring	April to September	60 to 70 days.
Cucumber	½ ounce	4 to 6 ft	4 to 6 ft	4 to 6 ft	1 to 2 in	February and March. [September.]	April to July	60 to 80 days.
Dandelion	¼ ounce	30 in	18 to 24 in	8 to 12 in	⅛ in	Early spring or autumn	Early spring	6 to 12 months.
Eggplant	½ ounce	30 to 36 in	24 to 30 in	18 to 24 in	½ to 1 in	February to April	April and May. (Start in hotbed during March.)	100 to 140 days.
Endive	1 ounce	30 in	18 in	8 to 12 in	½ to 1 in	February to April	April. [July]	90 to 180 days.
Horse-radish	70 roots	30 to 40 in	24 to 30 in	14 to 20 in	3 to 4 in	Early spring	Early spring	1 to 2 years.
Kale, or borecole	¼ ounce	30 to 36 in	18 to 24 in	18 to 24 in	½ in	October to February	August and September. [March and April.]	90 to 120 days.
Kohl-rabi	¼ ounce	30 to 36 in	18 to 24 in	4 to 8 in	½ in	September to March	March to May	60 to 80 days.
Leek	½ ounce	30 to 36 in	14 to 20 in	4 to 8 in	1 in	May to September	March to May	120 to 180 days.
Lettuce	½ ounce	30 in	12 to 18 in	4 to 6 in	½ in	September to March	March to September	60 to 90 days.
Melon, muskmelon	½ ounce	6 to 8 ft	6 to 8 ft	Hills 6 ft	1 to 2 in	February to April	April to June. (Start early plants in hotbed during March.)	120 to 150 days.
Melon, watermelon	1 ounce	8 to 12 ft	8 to 12 ft	Hills 10 ft	1 to 2 in	March to May	May and June	100 to 120 days.
Mustard	¼ ounce	30 to 36 in	12 to 18 in	4 or 5 to ft	¼ in	Autumn or early spring	March to May. [September]	60 to 90 days.
New Zealand spinach	1 ounce	36 in	24 to 36 in	12 to 18 in	1 to 2 in	Early spring	Early spring	60 to 100 days.
Okra, or gumbo	2 ounces	4 to 5 ft	3 to 4 ft	24 to 30 in	1 to 2 in	February to April	May and June	90 to 140 days.
Onion, seed	1 ounce	24 to 36 in	12 to 18 in	4 or 5 to ft	½ to 1 in	October to March	April and May	130 to 150 days.
Onion, sets	1 quart of sets	24 to 36 in	12 to 18 in	4 or 5 to ft	1 to 2 in	Early spring	Autumn and February to May.	90 to 120 days.
Parsley	¼ ounce	24 to 36 in	12 to 18 in	3 to 6 in	⅛ in	September to May	September and early spring	90 to 120 days.
Parsnip	½ ounce	30 to 36 in	18 to 24 in	5 or 6 to ft	½ to 1 in		April and May	125 to 160 days.
Peas	1 to 2 pints	3 to 4 ft	30 to 36 in	15 to ft	2 to 3 in	September to April	March to June	40 to 80 days.
Pepper	⅛ ounce	30 to 36 in	18 to 24 in	15 to 18 in	½ in	Early spring	May and June. (Start early plants in hotbed during March.)	100 to 140 days.
Physalis	½ ounce	30 to 36 in	18 to 24 in	18 to 24 in	½ in	March to May	May and June	130 to 160 days.
Potato, Irish	5 lbs. (or 9 bu. per acre).	30 to 36 in	24 to 36 in	14 to 18 in	4 in	January to April	March to June	80 to 140 days.
Potato, sweet	3 lbs. (or 75 slips).	3 to 5 ft	3 to 5 ft	14 in	3 in	April and May	May and June. (Start plants in hotbed during April.)	140 to 160 days.
Pumpkin	½ ounce	8 to 12 ft	8 to 12 ft	Hills 8 to 12 ft.	1 to 2 in	April and May	May to July	100 to 140 days.
Radish	1 ounce	24 to 36 in	12 to 18 in	8 to 12 to ft	½ to 1 in	September to April	March to September	20 to 40 days.
Rhubarb, seed	½ ounce	36 in	30 to 36 in	6 to 8 in	½ to 1 in		Early spring	2 to 4 years.
Rhubarb, plants	33 plants	3 to 5 ft	3 to 5 ft	3 ft	2 to 3 in		Autumn or early spring	1 to 3 years.
Rutabaga	¼ ounce	30 to 36 in	18 to 24 in	6 to 8 in	½ to 1 in	August and September	May and June	60 to 80 days.
Salsify	1 ounce	30 to 36 in	18 to 24 in	2 to 4 in	½ to 1 in		Early spring	120 to 180 days.
Spinach	1 ounce	30 to 36 in	12 to 18 in	7 or 8 to ft	1 to 2 in	September to February	September or very early spring.	30 to 60 days.
Squash, bush	½ ounce	3 to 4 ft	3 to 4 ft	Hills 3 to 4 ft.	1 to 2 in	Spring	April to June	60 to 80 days.
Squash, late	½ ounce	7 to 10 ft	7 to 10 ft	Hills 7 to 9 ft.	1 to 2 in	Spring	April to June	120 to 160 days.
Tomato	⅛ ounce	3 to 5 ft	3 to 4 ft	3 ft	½ to 1 in	December to March	May and June. (Start early plants in hotbed during February and March.)	100 to 140 days.
Turnip	½ ounce	24 to 36 in	18 to 24 in	6 or 7 to ft	¼ to ½ in	August to October	April. [July]	60 to 80 days.
Vegetable marrow	½ ounce	8 to 12 ft	8 to 12 ft	Hills 8 to 9 ft.	1 to 2 in	Spring	April to June	110 to 140 days.

SEED BEDS.

The gardener may find it desirable to reserve a small area of his garden for a seed bed in which some of the second crops for his rotations may be grown while the ground in which they are to develop is still occupied. In this way also advantage is taken of the fact that transplanting makes for stockiness. In seed-bed culture much the same practices are in force as in growing plantlets in flats and frames. The rows of seeds, however, are not spaced so closely in the outdoor seed beds as in the boxes and frames. When the plantlets crowd they may be thinned out or transplanted to another part of the seed bed. Late cabbage, lettuce, Brussels sprouts, cauliflower, etc., are plants that in many cases may be treated conveniently in this way.

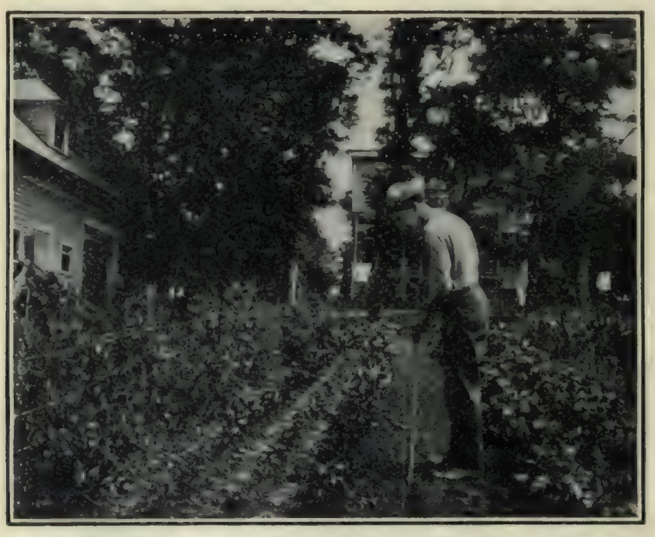

FIG. 9.—Use of a rake handle and line in opening a furrow for planting.

PLANTING PRACTICES.

In planting many kinds of seeds in the garden thick sowings are made to insure a good stand, and the superfluous plants later are pulled up. Straight rows or drills should be used in all cases. The use of a line will make accuracy possible. The line is stretched between stakes at the ends of the row, and with this as a guide the furrow is then opened. This may be done with the end of a hoe or rake handle (fig. 9), with the corner of a hoe, or the point of a special furrow hoe, with a hand plow, or with the edge of a board pressed into the loosened soil. Small seeds may be shaken out of the packet by hand in a thin stream while the packet is held close to the bottom of the furrow. Larger seeds, like peas and beans, may be dropped from the hand. Mechanical planters, built like wheel hoes, may be purchased if the size of the garden justifies their use.

DRILLS, ROWS, AND HILLS.

Small plants which are to be left almost touching each other, as is the case with onions and carrots, are said to be grown in drills. Plants grown at fixed distances, as cabbages or potatoes, are in rows. When plants are grown at distances of several feet apart in both directions they are said to be in hills. Furrows are opened for planting in both drills and rows. Hills, however, may be opened with a spade or trowel. An excellent method of using fertilizer is to apply it in the drills, rows, or hills before planting. In such cases the fertilizer should be mixed carefully with the soil in the bottom of the opening before the seeds are deposited.

FINAL PLANTING TOUCHES.

In planting the gardener should keep in mind that to germinate and develop properly into sturdy plants the seed must be firmly imbedded in well-fined, moist soil. The condition of the soil beneath the seeds is most important, since it is in this soil that the rootlets on emerging must find sustenance. Air spaces or cracks may cause the rootlets to shrivel. It is well, therefore, especially if the soil is at all dry, to force the seeds gently into the soil, compacting it slightly. This may be done with the back of a hoe in the case of small seeds, or with the ball of the foot when large seeds such as beans and peas are being planted. The seeds should then be covered immediately with soil. This should be very slightly compacted over the seeds with the back of the hoe. If weather conditions are such that there is a tendency for the soil to bake over the drills and rows before the plants appear, it is well to rake very lightly with a steel-tooth rake. It may be necessary, also, to work the ground at the sides of the rows as the plants are breaking through the surface. This should be done very carefully to avoid injury to the tender shoots.

SETTING OUT PLANTS.

Plants grown in flats, hotbeds, or cold frames should be "hardened off" as has already been suggested, before they are to be planted out of doors. Another preliminary step, if the plants are too tall or succulent, is to trim away about one-half of the large leaves. Several hours before transplanting the plants should be watered thoroughly, so that the soil will be moist enough to stick to the roots in balls of considerable bulk. After staking out rows and marking planting positions, lift the plants out with a trowel, keeping as much soil as possible on the roots. Cut or tear the plants apart when their roots are intertwined.

If the ground is moist, merely open a hole with a trowel or dibble, insert the earth-incased roots of a plant, draw soil up to the stalk and firm with knuckles and the balls of thumbs. If the soil is at all dry, pour about a pint of water into each hole before the plant is set. The surface about each plant should be raked carefully when all the plants are set.

Transplanting (fig. 10) should be done if possible in cloudy weather or late in the afternoon. If the weather is especially bright it may be necessary for a day or two to shade the plants with newspapers folded in inverted V shape and held in place with stones, earth, or other material.

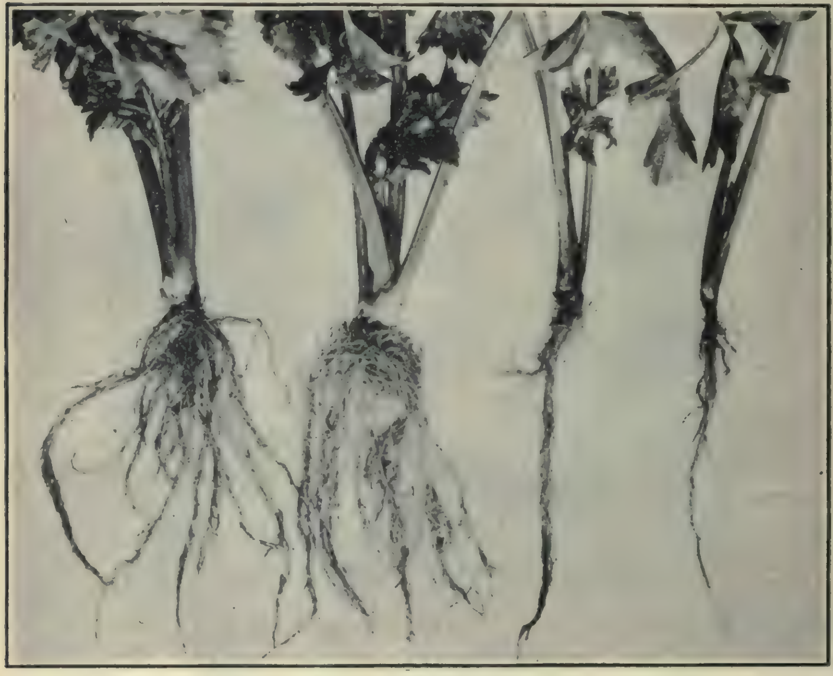

FIG. 10.—Transplanting stimulates branching root growth. Celery plants on the left were transplanted; those on right were not transplanted.

The quickest crop to mature is the radish. Lettuce, turnips, peas, beets, and beans usually require 6 to 9 weeks to mature; cabbage, potatoes, early peas, onion sets, and salad greens, 10 to 12 weeks; corn from 11 to 13 weeks, and potatoes from 15 to 16 weeks.

SUCCESSIONS AND ROTATIONS.

Since a number of vegetables reach maturity early in the season. it is possible to utilize the space they occupied for successive plantings of the same vegetables or for rotation plantings of different plants. The earliest of all the vegetables to mature is the radish. The gardener generally can count on being able to utilize anew the space occupied by the first planting of these vegetables in from 5 to 7 weeks, depending on the rapidity with which they are consumed. In intensive gardening, however, it is not necessary to wait until all the radishes of the first planting have been removed before other plantings can be made. Enough of the roots can be removed at intervals to make places for setting lettuce, cabbage, cauliflower, Brussels sprouts, or other plants, and the two crops—radishes and the interplanted crop—can continue growing side by side until the former is used. In a similar way onion sets may be set out in rows that are to be occupied later by tomato plants, room being made for the latter by the removal of a few onions when the proper planting time for tomatoes arrives. Various combinations of this sort can be worked out between quick-maturing crops and the plants grown in frames or seed beds for later planting in the open.

The gardener should not plant all of his radish, lettuce, or spinach seed at once, but should make several successive plantings at intervals of about two weeks. In this way the season for these vegetables will be lengthened greatly. Successive planting is possible also with beets, peas, beans, sweet corn, and a number of other vegetables. The best of the successive crops of the quick-maturing vegetables must be crowded into the early part of the season, since most such plants do not thrive well when planted in hot weather. This is especially true of radishes and lettuce. In the case of lettuce this disadvantage can be overcome to a certain extent by artificial shading.

In all sections but the extreme north it usually is possible to grow fall crops of certain vegetables, notably carrots, beans, radishes, Irish potatoes, and turnips. In the southern part of the country an even larger number of vegetables may be grown in the fall. The seeds for these late crops are planted from July to September, depending on whether the garden is in the northern or southern States.

In planting rotations of crops, whether the rotations be during the same or in succeeding seasons, certain general principles should be kept in mind. In type and character of growth the succeeding plant should differ as widely as possible from the plant which it follows. This is both for the purpose of avoiding attacks by insects and diseases, and to insure that the second crop shall be properly nourished. A good plan is not to have root plants, such as beets and carrots, nor plants of the same family, such as cabbage and Brussels sprouts, or tomatoes and peppers, follow each other. It is well to divide the plants into root crops, fruiting crops, and foliage crops, and have members of the different groups alternate.

For the convenience of gardeners who wish to plan to use their soil to best advantage by means of successive plantings and rotations, the following groupings of vegetables are made:

1. Crops Occupying the Ground all Season.

Asparagus.
Rhubarb.
Beans, pole snap.
Beans, pole Lima.
Beets, late.
Carrots, late.
Parsnips.
Salsify.
Corn, late.
Cucumbers.
Melons.
Squash.
Pumpkins.
Tomatoes.
Eggplant.
Peppers.
Onions (from seeds).
Leeks.
Okra.
Potatoes, main crop.
Rutabagas.

2. Successive Crops.

Radish.
Spinach.
Lettuce.
Peas.
Beans, dwarf.
Parsley.
Turnips.
Kohl-rabi.

3. Early Crops Which May be Followed by Others.[1]

Onion sets.
Beets, early.
Turnips, early.
Carrots, early.
Corn, early.
Cabbage, early.

4. Late Crops Which May Follow Others.[2]

Beets, late.
Spinach.
Peas, late.
Celery.
Cabbage, late.
Brussels sprouts.
Cauliflower.
Kale.
Endive.
Flat turnips.

CULTIVATION.

The importance of cultivation has been referred to in the discussion of the preparation of the seed bed. It is, however, after the seeds have sprouted or after the plants have been set in their permanent locations that cultivation becomes of major importance. The gardener should never permit the surface of the soil to become baked or even to form an appreciable crust. Constant stirring with hand tools or a wheel cultivator should be practiced between the rows and about the plants. Such a stirring permits the air to penetrate the soil, where it facilitates chemical action and bacterial activity, destroys weeds which otherwise would utilize large amounts of plant food, and, finally, conserves the moisture supply. The rake is perhaps the gardener's most valuable tool in cultivating. This can be passed backward and forward over the ground until it is in an open, mellow condition. Where vegetables grow closely in the rows it often will be necessary to supplement the cultivation by hand weeding. Small implements are made for this purpose, and may be purchased cheaply. It is well also in some cases to pull up weeds by hand, especially where they grow closely about the stalks of the garden plants.

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[1] In addition to the vegetables listed in this group, all of those listed in Group II may be followed by other crops.

[2] Group II crops also may follow early crops.

STIRRING THE SOIL AFTER RAINS.

Just as the gardener should be careful in early spring not to dig the ground when the soil is too moist, so he should be careful later in the season not to cultivate too soon after rains. The stirring of very muddy soil "puddles" it into a compact, cement-like mass in which the plant food is securely locked. The garden will require attention, however, as soon as the excess moisture from a rain has soaked in or partially evaporated. Unless the ground is stirred at this time a crust will form almost inevitably. Such a crust, besides restricting the plants, prevents the access of air, and also facilitates the loss of moisture through evaporation.

IRRIGATION.

When, during prolonged dry spells, the plants give evidence of suffering because of the lack of moisture, water must, if possible, be supplied artificially. Where a supply of piped water is at hand, perhaps the most usual method of irrigation is by sprinkling with a hose. If sprinkling is practiced it should be done late in the afternoon. It is not sufficient merely to dampen the surface; a thorough wetting should be given. A more satisfactory and more economical method of irrigation, however, is to open small furrows between the rows of growing plants and to supply water in these ditches from a hose or pipe. Several hours after the water has soaked in, the dry earth should be drawn back into place.

PROTECTING PLANTS FROM DISEASES AND PESTS.

Unfortunately the gardener is not assured of success when his plants have started to grow thriftily. He must count almost inevitably upon the presence in his garden of plant diseases and pests, which, if not combated, will interfere seriously with his yields or even destroy his plants. It is hard for some gardeners to realize the importance of making early provision to combat these enemies of plant life. It can not be too strongly emphasized, however, that such provision is of equal importance with other phases of gardening and that it should under no circumstances be neglected. The wise gardener does not wait for the appearance of insects and diseases, but takes steps to combat them by spraying the plants at reasonable intervals from early spring until his crops have been harvested, or by other protective measures. He thus insures himself against the likelihood of loss.

The necessary implements and materials for protecting the home garden against insects and diseases should be assembled early in the season. These consist of a substantial hand sprayer and the necessary concentrated solutions, which, after dilution with water, are to be sprayed on the plants.

The diseases which affect garden plants may be divided into two groups, parasitic and constitutional diseases. The parasitic maladies, such as the blights, are caused by fungi or germs, and usually may be prevented or controlled by spraying with Bordeaux mixture. Little is known, however, of the so-called constitutional diseases, and little can be done to prevent their ravages. If some malady which does not yield to treatment with Bordeaux mixture manifests itself on isolated plants in the garden, it may be well to pull up these plants and burn them.

The insects which attack garden plants may be divided into two groups—those which eat or chew the fruit or foliage, and those which suck the plant juices. Eating insects may be killed usually by spraying poisonous solutions or dusting powders on the plants which they attack. Arsenate of lead is the poison in most general use for this purpose. This substance is poisonous to persons as well as to insects and must be used with care. It should not be applied to vegetables that are to be used soon. All vegetables should be washed carefully before they are eaten, regardless of whether they have been sprayed.

Most of the garden plants may be guarded against disease and at the same time protected from attack by eating insects by spraying at intervals of two weeks with a combination of Bordeaux mixture and arsenate of lead.

Other methods of protecting plants from the larger eating insects are to pick the pests by hand or knock them with a stick into a pan containing water on which a thin film of kerosene is floating. Insects collected by hand should be destroyed promptly. Young plants may be protected by setting over them wooden frames covered with mosquito netting, wire mesh, or cheesecloth. Cutworms may be kept from plants by setting tin or paper collars into the ground around the stalks.

Sucking insects, such as plant lice, can not be killed by poisoning the surface of the leaves and fruit, since they feed by puncturing the plants and extracting the internal juices. Poisons which will kill by contact or substances which envelop and smother the pests are, therefore, employed against the sucking insects. The principal remedies of this sort are nicotine solutions, fish-oil and other soap solutions, and kerosene emulsion.

The following table lists the insects most likely to appear in the vegetable garden and furnishes information in regard to the plants attacked and the treatment recommended:

Principal insects and remedies.[1]

Insect.	Plants attacked.	Treatment.
Eating type:		
Tomato worms	Tomato	Hand pick or spray with arsenate of lead.
Cabbage worm	Cabbage group	Hand pick or apply arsenate of lead.
Cucumber beetles	Cucumber	Cover with frames. Apply tobacco dust or spray with Bordeaux mixture or arsenate of lead.
Cutworms	Tomato, cabbage, onion	Apply poison bait; place tin or paper collars around plants; hand pick; apply Paris green or arsenate of lead.
Potato beetle	Potato, eggplant, and tomato	Hand pick and apply arsenate of lead.
Sucking type:		
Squash bug	Squash, pumpkin, melons, etc.	Hand pick; spray with kerosene emulsion or nicotine sulphate.
Aphis (plant lice)	Cabbage group and other plants.	Spray with kerosene emulsion, a solution of hard soap, or nicotine sulphate.

Gardeners desiring additional information in regard to insects affecting the vegetable garden should apply direct to the Bureau of Entomology, United States Department of Agriculture, but it should be understood that there is no publication covering the entire subject. Specimens of insects with some account of food plants and ravages should accompany correspondence.

The gardener should remember that many plant diseases and insects exist in the garden from year to year. At the end of the growing season, therefore, the garden should be carefully cleaned of rubbish, the stems of plants, leaves, etc. It is necessary to burn this débris promptly, as any disease spores or insects which may be present are then surely destroyed.

FIG. 11.—Head lettuce produces very tender, almost white leaves in the center of the heads, but is somewhat harder to grow than the loose-leaf sorts.

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[1] Methods of protecting gardens against grasshoppers are given in Farmers' Bulletin 691, "Grasshoppers and Their Control on Sugar Beets and Truck Crops."

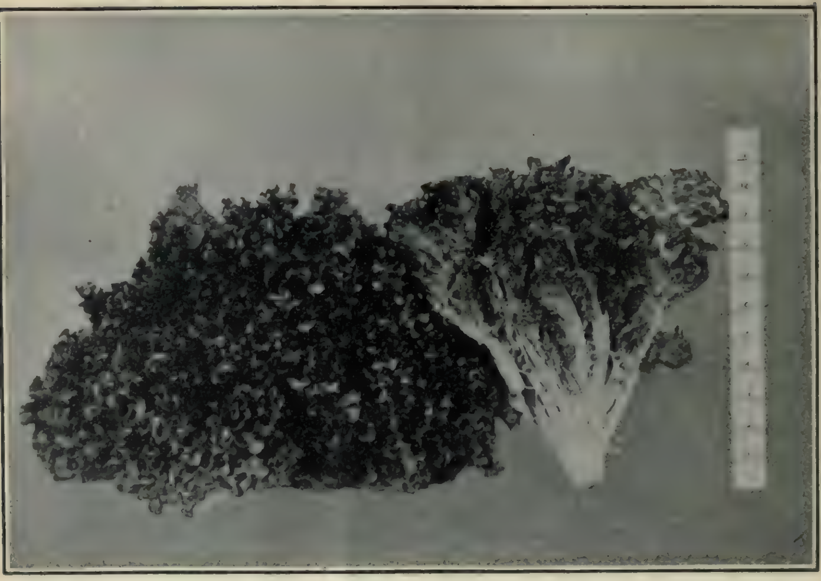

FIG. 12.—Loose-leaf or open-headed lettuce is excellent for growing in the home garden, since its cultural requirements are not so exacting as those of head lettuce.

CULTURAL SUGGESTIONS FOR THE COMMONER VEGETABLES.

RADISH.

Radishes are so hardy that they may be grown through the winter in cold frames in the latitude of Washington and farther South in the open ground. In the North they require hotbeds, but can be sown in the open ground as soon as the soil is moderately warm. They should be planted in drills 12 to 18 inches apart and thinned slightly as soon as the plants are up. On a quick, rich soil some of the earlier varieties can be matured in from three to four weeks after planting. If the plants are allowed to remain long in the open ground, the roots lose their crispness and delicate flavor, and in order to secure a constant supply successive plantings should be made every two weeks. One ounce of radish seed is sufficient to plant 100 feet of row. A large percentage of the seed germinates, and if the sowing is done carefully later thinning may be unnecessary. The first radishes to appear may be pulled as soon as they are of sufficient size, and this will leave enough room for those that are a little later. The plant is not suited to hot weather, but should be planted in the early spring and late autumn.

LETTUCE.

Lettuce does not withstand heat well and thrives best, therefore, in the early spring or late autumn. In order to have the leaves crisp and tender it is necessary to force the growth of the plant. The usual method of growing lettuce for home use is to sow the seeds broadcast in the bed and to remove the leaves as rapidly as they become large enough for use. It is better, however, to sow the seeds in rows 14 to 16 inches apart, and when the plants come up to thin them to the desired distance. With the heading type this should be about 12 inches apart. This will result in the formation of rather compact heads and the entire plant may then be cut for use. For an early crop in the North, the plants should be started in a hotbed or cold frame and transplanted as soon as hard freezes are over. In many sections of the South the seeds are sown during the autumn and the plant allowed to remain in the ground over winter. Frequent shallow cultivation should be given the crop and, if crisp, tender lettuce is desired during the summer months, some form of partial shading may be necessary.

For head lettuce (fig. 11), Big Boston, Hanson, and California Cream Butter are good varieties. For loose-leaf lettuce (fig. 12), Grand Rapids or Black-seeded Simpson is recommended.

PEAS.

Garden peas are not injured easily by light frosts and may be planted as soon as the soil can be put in order in the spring. By selecting a number of varieties it is possible to have a continuous supply of peas throughout a large portion of the growing season. In order to accomplish this plantings should be made every 10 days or 2 weeks until warm weather comes. The first plantings should be of small-growing, quick-maturing varieties, such as Alaska, First and Best, and Gradus. These kinds do not require supports. They

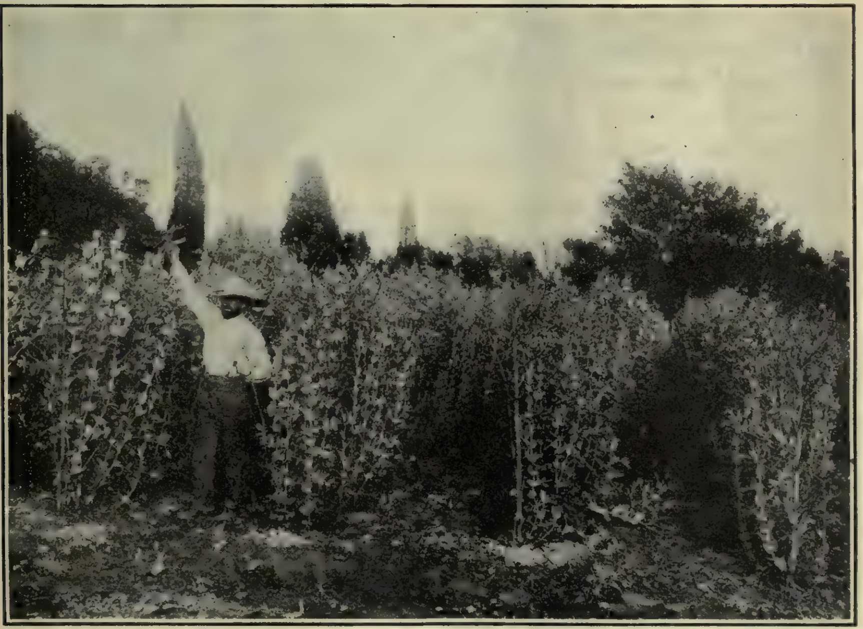

FIG. 13.—Tall-growing garden peas supported by brush stuck into the ground.

should be followed by the large wrinkled type of peas, such as Champion of England, Telephone, and Prize Taker. These may be supported on brush (fig. 13), on strings attached to stakes driven in the ground, or on wire netting.

Peas should be planted about 2 to 3 inches deep in rows 3 to 4 feet apart. Some gardeners, however, follow the practice of planting in double rows 6 inches apart, with the ordinary space of 3 to 4 feet between these pairs of rows. With varieties requiring support this is a good practice, as the supports can be placed in the narrow space between the rows.

ONIONS.

The onion will thrive under a wide range of climate and soil conditions, but a rich sandy loam containing plenty of humus is best suited to it. (Fig. 14.) As the crop requires shallow cultivation and it may be necessary to resort to hand work in order to keep it free from weeds, it is very desirable that the land should be in such condition that it is easily worked. As a general rule it is well to have the crop follow some other that has been kept under the hoe and free from weeds the previous season.

FIG. 14.—Onions are easily grown on good soil and require little attention besides weeding.

In the North seed is sown as early in the spring as the soil can be brought to the proper condition. In the South onion sets are frequently put out in the autumn and carried through the winter with the protection of a little hay or straw. There are three methods of propagating onions: The first by sowing the seed in rows where the crop is to grow; second, by sowing the seed in specially prepared beds and transplanting the seedlings to the open ground; and, third, by planting sets which have been kept through the winter. The first method is used by large commercial growers on account of the amount of labor involved in the others.

On small areas, however, it may be preferable to plant sets. Under normal conditions these usually may be obtained at planting time for about 25 or 30 cents a quart. This should be enough for the average family. Onions planted from sets will ripen earlier than those from seed sown in the fields.

When the transplanting method is used, the seed is sown in greenhouses, hotbeds, cold frames, or specially prepared beds at the rate of 3½ to 4 pounds for each acre to be planted. One-half ounce should furnish plants sufficient for the home garden. The seedlings are transplanted when they are somewhat smaller than a lead pencil and rather stocky. The root end of the seedling is pushed into the soil with one finger, and the soil is then firmed about the plant.

The seed is sown thickly in drills about 12 to 14 inches apart. After the plants become established they are thinned to 2 or 3 inches apart. The maturity of the bulbs may be hastened by preventing the continued growth of the tops. This is sometimes accomplished by rolling an empty barrel over the rows and breaking down the tops. After these are practically dead the onion bulbs may be pulled up by hand from the soil and spread in a dry, well-ventilated place to cure. Thereafter they may be stored in crates or bags for winter use. In the North the crop ripens and is harvested during the latter part of the summer and early autumn. In the Southern States, where the crop is grown during the winter, the harvesting and marketing period takes place during the spring months.

There are several kinds of onions that may remain in the soil over winter. The multiplier, or potato onion, for example, can be planted from sets in the autumn and will produce excellent green early onions. A large onion of this type contains a number of distinct hearts, and, if planted, will produce a number of small onions. On the other hand, a small onion contains but one heart and will produce a large onion. A few of the large ones may be planted each year to produce sets for the following year's planting.

The shallot is a variety of small onion that is frequently planted in early spring for its small bulbs, or "cloves," which are used in the same manner as onions. The leaves are utilized for flavoring. Another onion-like plant is the chive, the small, round, hollow leaves of which are used for flavoring soups. These leaves may be cut freely, as they are soon replaced by others.

THE PRINCIPAL ROOT CROPS.

Beets (fig. 15) can be planted comparatively early in the season. It is not necessary to wait until the ground has become warm, if the danger of frost is past. The seed should be sown in drills 14 to 18 inches apart and covered to a depth of about 1 inch. As soon as the plants are well up they should be thinned to stand 3 to 4 inches apart. From 2 to 3 plantings should be made in order to have a continuous supply of young, tender beets.

Parsnips, salsify, carrots, and turnips are all handled much like beets. Of the five, carrots can perhaps be left closer in the row than the others, about 2 or 3 inches apart. This plant, too, is less exacting in so far as fertility is concerned. Salsify, on the other hand, demands very fertile and finely cultivated soil.

POTATOES.[1]

The potato plant thrives best in sandy or gravelly loam soils. It may be grown with a fair degree of success on any type of soil except loose sand and a heavy, sticky clay, provided the land is well drained and contains the necessary plant food.

Successful potato production is dependent to a large extent on the thoroughness with which the land is prepared before planting the crop. Where a horse can be used, the land should be plowed from 8 to 10 inches deep, provided the surface soil is of a sufficient depth to permit it. It is never advisable to turn up more than 1 inch of raw subsoil at any one plowing; so if previous plowings have not been over 6 inches, the maximum depth at which it should be plowed is 7 inches.

Where hand labor is employed the same rule should govern as to depth. In spading, especially on grass or waste land, turn the earth bottom side up. Whether the land is plowed or spaded, it should be thoroughly pulverized immediately afterwards. Where horse labor can be used, the land after plowing should be thoroughly disked first, then spring-toothed, and finally finished with a smoothing harrow. Where land must be prepared by hand, it is good practice to pulverize the soil as much as possible when spading it up, after which it can be put in a fine condition of mellowness with a steel garden rake. The importance of thoroughly fining the soil can not be overemphasized.

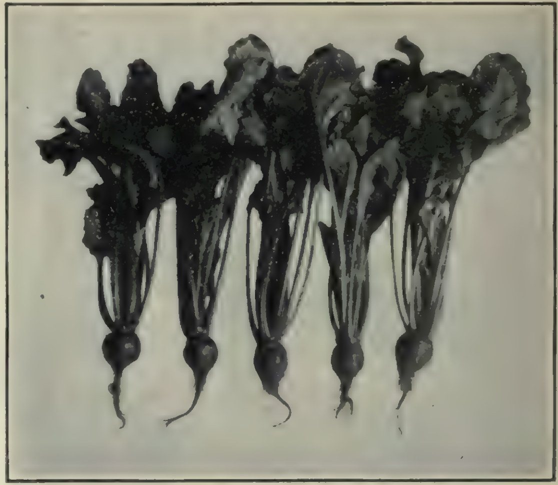

FIG. 15.—Both the roots and foliage of young beets may be eaten, cooked together or separately.

VARIETIES ADAPTED TO DIFFERENT LOCALITIES

Early varieties.—In the Northeastern United States and along the South Atlantic seaboard, the Irish Cobbler, Early Petoskey, or Early

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[1] Circular 87 of the Bureau of Entomology deals with the Colorado potato beetle, and Farmers' Bulletin 557 deals with the Potato tuber moth.

Standard, all of which are practically identical, may be expected to produce larger crops and be more generally satisfactory for an early crop than the others mentioned. Quick Lunch and New Queen would be regarded as second choices for this section.

In the South Central and Southwestern States, the Triumph may be expected to give results equal to or even better than the Irish Cobbler.

In the Middle West, the Early Ohio should do well, while the Early Harvest and Early Rose may be regarded as second choices.

Late varieties.—In the New England States, Long Island, and northern New York, the Green Mountain, Gold Coin, Delaware, and other late varieties of that class do best.

In northern Michigan, Wisconsin, and Minnesota, the late varieties named above do about as well as the Rural New Yorker No. 2, and are superior to it in table quality.

In western New York, southern Michigan and Wisconsin, and Iowa, the Rural New Yorker No. 2, Sir Walter Raleigh, and Carman No. 3 are the best adapted varieties, and divide honors with the Green Mountain in the northern portions of these States.

Throughout Maryland, Virginia, the Carolinas, Tennessee, and Georgia, the variety known as McCormick is quite generally grown as a late variety. In a favorable season the Green Mountain can also be grown.

WHEN TO PLANT POTATOES.

The date of planting necessarily must be governed by climatic conditions. In attempting to produce as early a crop as possible some risk must always be incurred of the plants being injured by late spring frosts. As a general proposition it is best to plant potatoes as soon as there is little likelihood of killing frosts after the plants are up and the ground is in condition to work.

The following dates of planting for various cities should be regarded only as the approximate time at which early potatoes might safely be planted:

March 15 to 25: Washington, Baltimore, Philadelphia, Cincinnati, Louisville, St. Louis.

March 25 to April 5: New York, Indianapolis, Detroit, Chicago.

April 5 to 15: Boston, Albany, Rochester, etc.

In the northern cities late varieties should be planted from three to four weeks later.

PLANTING PRACTICES.

The usual method of preparing potatoes for planting is to cut them into rather large pieces, containing several eyes. When seed potatoes are unusually expensive, however, it may be well to cut cone-shaped segments of meat around each eye and to use the remaining portion of the tubers for food. Under this plan it is not necessary to prepare the seed all at one time. From day to day the cones for seeding can be cut from the potatoes as they are being prepared for the table. The cuttings then should be spread out on a piece of paper in a moderately cool room (about 50° F.) and allowed to remain there until they have cured; that is, until the cut surface has become dry. A day or two should suffice for this, and potatoes then should be put in a shallow box or tray and placed where it is still cooler. Any storage condition that will insure them against frost on the one hand and undue shriveling on the other should prove satisfactory.

These seeds can be started indoors, provided it is possible to secure suitable soil and boxes. In such cases it may be desirable to plant the eye cuttings at once, and allow them to start into growth indoors with the idea of transplanting them into the open ground when danger of frost is past and the ground is dry enough to be cultivated.

The smaller the size of the set, or seed piece, used the more thorough must be the preparation of the soil. The more finely the soil is pulverized and the more uniform the moisture conditions which can be preserved in the soil, the better is the chance for the small seed piece to establish itself. A small set in rough, lumpy, or dried-out soil has little chance to live.

Generally speaking, the smaller the size of the set the closer it should be planted in the row if maximum yields are to be secured. Such sets may be expected to give the best yields if not spaced more than 10 to 12 inches apart in the row. Plant the small eye cuttings from 1½ to 3 inches deep, depending upon the character of the soil—the lighter the soil the greater the depth of planting. Larger sets may be planted 4 inches deep.

SPACING.

If an early variety is planted, and the work is to be done by hand, the rows may be spaced as close as 26 inches, whereas if cultivation is to be done with a horse, 30 to 34 inches usually is allowed. In order to give the gardener some idea of the number of sets required to plant a plot of ground 50 by 100 feet at different spacings, the following table is submitted:

To plant a plat 50 by 100 feet.

Space between rows.	Space in row between plants.	Sets required.	Space between rows.	Space in row between plants.	Sets required.
Inches.	*Inches.*		*Inches.*	*Inches.*	
26	10	2,769	30	10	2,400
26	12	2,487	30	12	2,000
28	10	2,678	32	12	1,874
28	12	2,231	34	12	1,765

If a late variety is planted, the spacing should be greater, say, 34 to 36 inches between the rows and 12 to 14 inches between the plants in the row. The closeness of planting should be determined, first, by the variety, and, second, by the amount of available plant food and moisture in the soil or that can be applied to it.

CORN.

Corn (fig. 16) to be at its best should be eaten within a few hours after it is picked, for its sugar content disappears very rapidly after it is removed from the garden. For this reason and because of its very general popularity it is an excellent vegetable to grow in the home garden. It should be planted on rich land and cultivated in the same manner as field corn. Beginning as soon as the soil is warm, successive plantings may be made every two or three weeks until late summer. Another method of prolonging the supply is to plant early, medium, and late varieties. The seed should be planted about 2 inches deep, in drills 3 feet apart, and thinned to a single stalk every 10 to 14 inches.

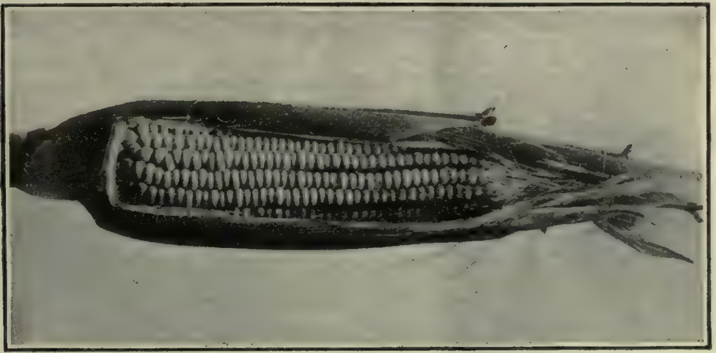

FIG. 16.—Green corn is one of the vegetables which loses much of its flavor if kept long after it is cut before being eaten. It should, therefore, be grown in the home garden if space permits.

The following varieties are recommended: For early corn, Golden Bantam and Adams Early, and for medium and late varieties, Black Mexican or Crosby's Early, Country Gentleman, and Stowell's Evergreen. The last-named variety has the largest ears and is the most productive.

Corn should be planted on rich land. The cultivation should be frequent and thorough and all weeds should be kept down and suckers removed from around the base of the plant.

TOMATOES.

Tomato plants should be started in the house or in a hotbed and should be transplanted once or twice in order that strong and vigorous plants may be secured by the time all danger from frost is past.

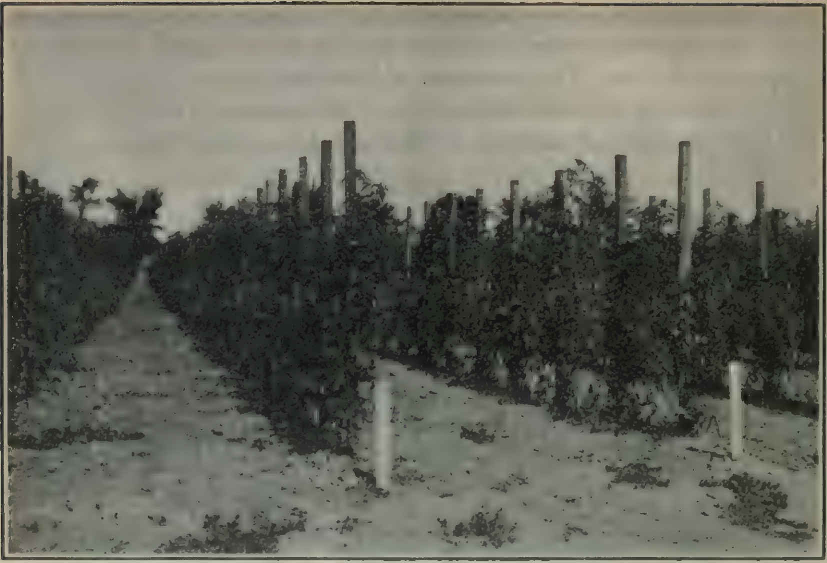

FIG. 17.—Tomato vines tied to stakes produce cleaner, healthier fruit than those permitted to trail on the ground, and giving the garden a more attractive appearance. The stakes need not be so large as those here pictured.

Pot-grown plants are especially desirable, as they may be brought to the blooming period by the time it is warm enough to plant them with safety in the garden. If the plants are not to be trained (fig. 17), but are to be allowed to lie on the ground, they should be set about 4 feet apart each way. If trimmed and tied to stakes they may be planted in rows 3 feet apart and 18 inches apart in the row. The home gardener will find the latter method preferable.

In common with all plants grown in a house, hotbed, or cold frame, tomatoes require to be hardened off before they are planted in the garden. By this process the plants are gradually acclimated to the effects of the sun and wind, so that they will stand transplanting to the open ground. Hardening off usually is accomplished by ventilating freely and by reducing the amount of water applied to the plant bed. The bed, however, should not become so dry that the plants will wilt or become seriously checked in their growth. After a few days it will be possible to leave the plants uncovered during the entire day and on mild nights.

EGGPLANTS AND PEPPERS.

Eggplants (fig. 18) and peppers are started and handled in the same way as the tomato. The soil best adapted for their production is a fine, rich sandy loam, well drained. The plants should be set in rows 3 feet apart and 2 feet apart in the row. Free cultivation is desirable, and the plants should be kept growing rapidly. A dozen good healthy plants each of eggplant and pepper should supply enough fruits for the average sized family throughout the season. Both of these vegetables are heat-loving and should not be set in the open until the ground has become warm.

BEANS.

Beans are more susceptible to cold than peas and should not be planted until danger of frost is past and the ground begins to warm up. They are, however, among the most desirable vegetables that the home gardener can raise. There are many different kinds and varieties of beans, but for garden purposes they may be divided into two classes—string and Lima. Both classes are grown in practically all parts of the United States where the frost-free period is greater than three months and adapt themselves to a wide diversity of soils and climate. They grow rapidly and, therefore, leave the area in which they have been planted free for another crop. To secure a continuous supply, it is desirable to make plantings at

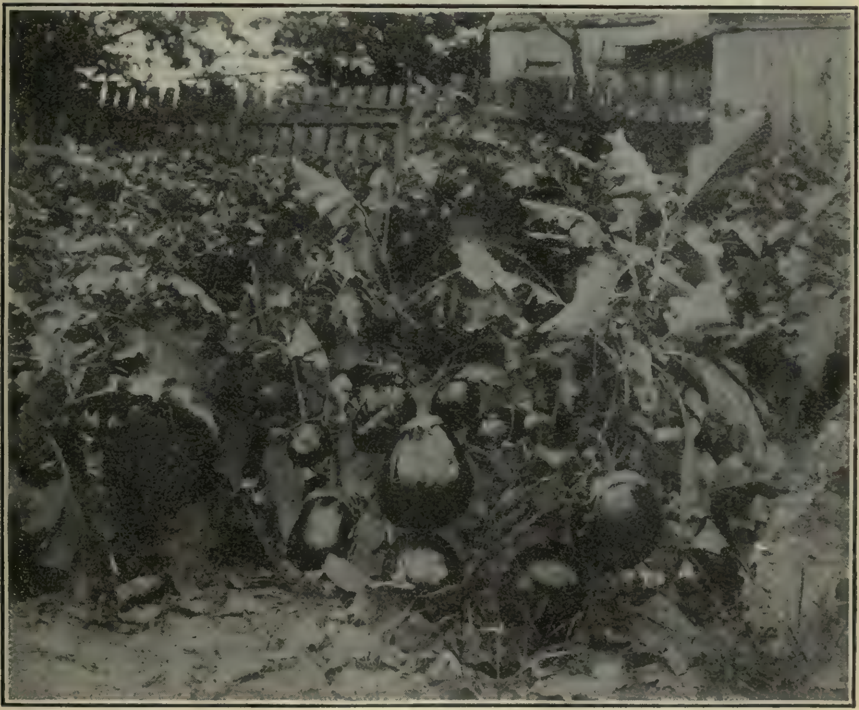

FIG. 18.—When grown under good soil and cultural conditions the eggplant is a prolific yielder. All the fruits shown in this illustration are on a single plant.

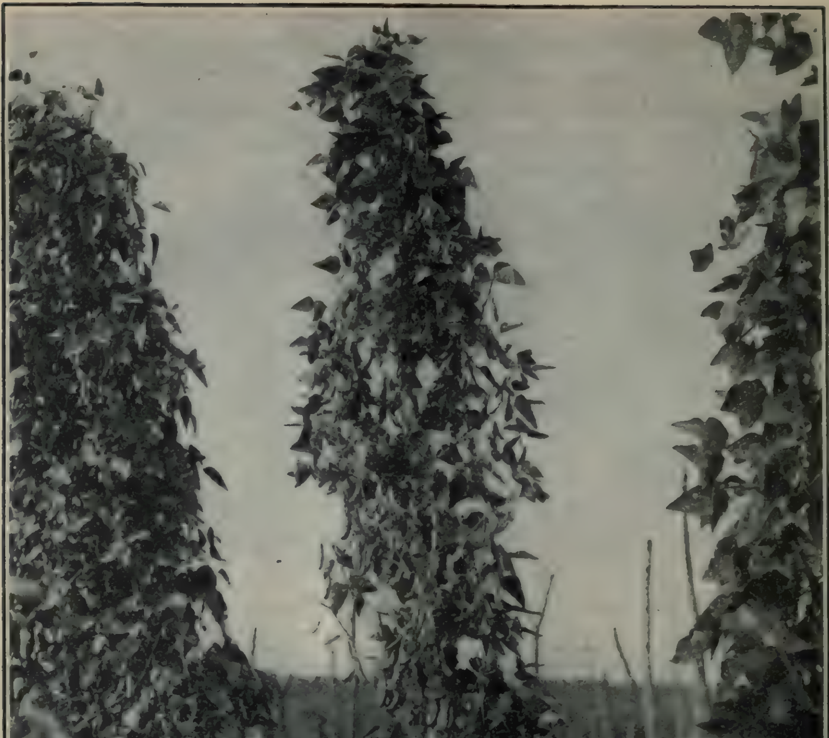

FIG. 19.—Pole lima beans are prolific bearers, as the illustration shows. Like other beans, they thrive on almost any soil. Vegetables that may be trained on poles or fences help to economize space in the small garden.

intervals of 10 days or 2 weeks from the time that the ground is reasonably warm until hot weather sets in.

Both string and Lima beans are subdivided into pole and bush types. Pole Lima beans (fig. 19) should be planted with from 8 to

10 seeds in the hill, and after the plants become established should be thinned to 3 or 4. The hills should be 4 or 5 feet apart. Bush Lima beans are planted 5 or 6 inches apart in rows 30 to 36 inches apart. Bush beans of the string type may be planted somewhat closer—the plants standing 3 or 4 inches apart in rows from 20 to 24 inches apart if hand cultivation only is to be employed.

Beans of any kind should not be planted any deeper than is necessary to secure good germination. This should never be over 2 inches and on heavy soil it should not be more than 1¼ to 1½ inches.

Beans are useful in the home garden, since they thrive on practically any type of soil. The pole varieties are especially convenient, since they can be planted along the edges of the yard and permitted to climb on the fences. Some of the pole beans, both snap and Lima, will continue to bear until frost. If the pole beans are planted in the hills in the garden proper, it will be necessary to sink a pole at each hill or to provide some other form of support. Extra long poles may be used and the tops of three or four from different hills fastened together tent fashion. If it is desired to keep the garden free from poles, substantial posts may be set at each end of the row and a wire or strong cord stretched between their tops. Cords may then be extended from small stakes in each hill to the wire.

FIG. 20.—Hubbard squash vines occupy considerable space but may be grown in the larger home gardens.

CUCUMBERS, SQUASHES, AND MELONS.

Cucumbers, squashes[1] (fig. 20), and melons all belong to the melon family and demand much the same treatment. All are heat-loving and should not be planted in the open until the ground has become warm. It is easily possible, however, to give the plants an early start in the house and so gain several weeks in earliness of maturity. One way is to plant seven or eight seeds in berry boxes filled with soil. Each box of growing plants should have its bottom removed at planting time and should then be sunk in the garden to constitute a hill of plants.

Instead of growing the plants in boxes of ordinary soil they may be grown on sods in a suitable receptacle. Cut sods 6 inches square from spots which the growth of grass shows to be rich. Turn these grass side down and press the seeds in among the roots and soil. Cover with about an inch and a half of good soil and keep moist and warm. At planting time the sods may be lifted and placed in hills, which first should have manure worked into them.

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[1] An insect that attacks squashes and other crops of this class is described in Farmers' Bulletin 668, "The Squash-vine Borer."

These plants are rank growers and occupy much space. In very small gardens it may be well, therefore, to omit them. If squashes are grown, it may be well to plant only bunch varieties. Space may be conserved by growing a few cucumber vines near the edge of the garden and training them on a fence. This is possible, too, of course, with some melons and pumpkins, but supports will be necessary for the fruits. If the plants of this group are grown in the main garden, they must be spaced from 6 to 12 feet apart each way.

CABBAGE, CAULIFLOWER, AND BRUSSELS SPROUTS.

Cabbage and the other two members of the cabbage family mentioned here require much the same treatment.[1] All three are grown in hotbeds, frames, or flats for the early crop and are set out when all danger of frost is past. Of the three, Brussels sprouts (fig. 21) is the hardiest. Cabbage is fairly hardy, but cauliflower is somewhat tender. All require rather moist soil and plenty of plant food. Fertilizer may be conserved by placing it under each "hill" before the plants are set. The settings should be made 18 to 24 inches apart in rows spaced about 24 inches.

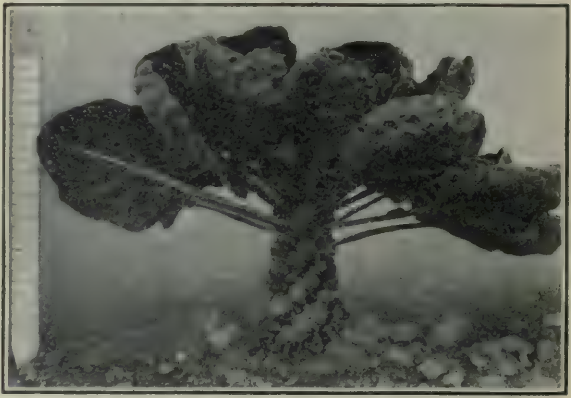

FIG. 21.—A single plant of Brussels sprouts. The miniature "heads" on the stalk are cut off and cooked like cabbage.

MISCELLANEOUS SALAD VEGETABLES.

Besides lettuce there are a number of vegetables for use as salads or cooked greens that may be grown easily in the home garden. Of the salad plants corn salad, garden cress, and endive are perhaps best known. The first two may be planted early. Endive, however, is planted in June and July. All are grown in drills about 14 inches apart and are thinned to proper distances as they grow.

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[1] Accounts of two insects that attack cabbage are given in Farmers' Bulletin 766, "The Common Cabbage Worm," and Circular 103 of the Bureau of Entomology, "The Harlequin Cabbage Bug."

Spinach and mustard are useful greens for cooking. Spinach may be grown either in the spring or in the fall. It is grown in drills, the use of the larger plants first automatically taking care of thinning.

Mustard greens may be produced on almost any good soil. The basal leaves are used for greens and are cooked like spinach. The plants require but a short time to reach the proper stage for use and frequent sowings should be made. The seeds are sowed thickly in drills as early as possible in spring or for late use in September or October. Ostrich Plume is a reliable variety.

For use both as a salad plant and for cooked greens Swiss chard (fig. 22), a beet which has been developed for foliage, should be more extensively grown. One of the good points about this vegetable is that crop after crop of leaves may be cut without injuring the plant. Chard is planted like beets in drills 12 to 14 inches apart and thinned to 4 to 6 inches.

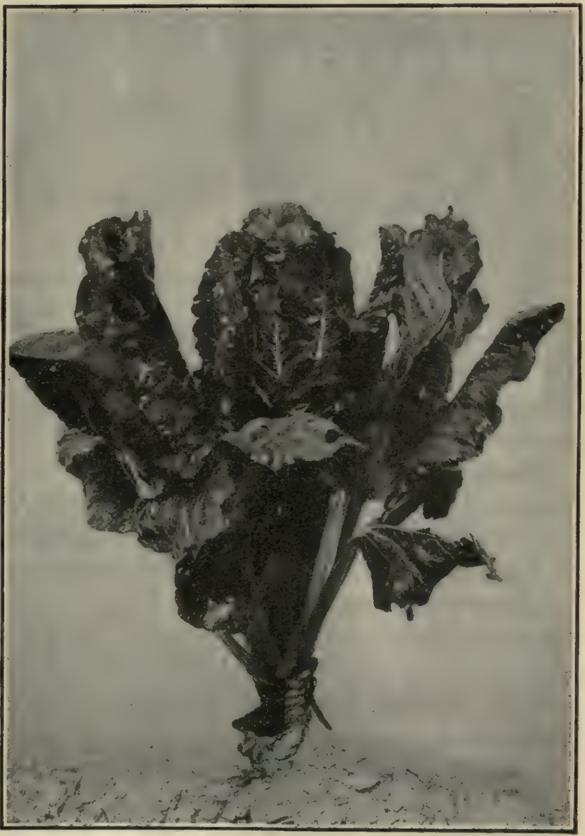

FIG. 22.—Swiss chard, a beet which has been bred for salad foliage instead of for root. The leaves and stalks may be cut repeatedly and used like spinach. Since the plant furnishes salad greens throughout the season it may well be grown instead of spinach, which furnishes but one crop, or after spinach.

PERMANENT VEGETABLES.

A number of vegetables, once established, will furnish a supply of their products year after year. Asparagus, rhubarb, and a number of garnishing and flavoring herbs are the best-known members of this group. Because they permanently occupy the space in which they grow, such plants should be in beds separated from the cultivated vegetables.

For the asparagus bed a well drained, early location should be chosen. Prepare the bed by digging a trench 18 inches wide and 20 inches deep. Fill this one-third full with well-rotted manure and tramp it down well. Half fill the remaining space with good soil, and on this set the root clumps of asparagus, 1 foot apart. Such roots, one, two, or three years old, may be purchased from seedsmen or nurseries. Cover the roots by filling the trench to the surface of the ground with good soil. The stalks should not be cut until a year after planting, and then but lightly. Full harvests may be taken after this. From a dozen to two dozen roots should be enough for the average family.

Rhubarb is also grown from root clumps. A row of six or eight plants, 4 feet apart, should furnish stalks enough for the average family. Each hill should be well prepared with manure and good soil. Set the crowns about 4 inches underground. Stalks should not be cut until a year after planting.

Parsley seeds are sown in a drill in spring. The plants will die down in the fall and put out fresh foliage the next spring. The plant is a biennial and must be replanted at two-year intervals.

Sage is a useful perennial herb which can be grown easily in the home garden. One or two bushes will furnish an abundance of leaves. These, when full grown, should be thoroughly dried and stored in cans or jars.

ANNUAL PLANTS USED FOR SEASONING.

Chives are small onionlike plants having flat, hollow leaves. These are cut and used for flavoring soups, sauces, etc. The plants are propagated by bulbs. A patch of the plants a foot or so square should be enough for the home garden.

Okra, or gumbo, produces pods which are used to season and thicken soups. The seeds of okra should be sown in the open after the ground has become quite warm, or the plants may be started in berry boxes in the hotbed or in the house and transplanted in the garden after all danger of frost has passed. The rows should be 4 feet apart for the dwarf sorts and 5 feet apart for the tall kinds, with the plants 2 feet apart in the row.[1] If the pods are removed before they are allowed to ripen, the plants will continue to produce them until killed by frost.

Cabbage, carrots, turnips, and rutabagas, in addition to their use as early crops, may be planted early in summer and the products which mature in autumn may then be held for winter use.

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[1] Detailed information on this plant is contained in Farmers' Bulletin 232, "Okra: Its Culture and Uses."

VEGETABLES FOR WINTER USE.

For a late crop of cabbage it is customary to plant the seeds in a bed in the open ground in May or June and transplant them to the garden in July. For cabbage of this character the soil should be heavier and more retentive of moisture than for early cabbage, which requires a rich, warm soil in order to reach maturity quickly. For the late variety it is not desirable to have too rich a soil, as the heads are liable to burst. Cabbages should be set in rows 30 to 36 inches apart, the plants standing 14 to 18 inches apart in the row.

To store cabbage for winter the heads should be buried in pits or placed in cellars. One method is to dig a trench about 18 inches deep and 3 feet wide and set the cabbage upright with the heads close together and the roots embedded in the soil. When cold weather comes the heads are covered lightly with straw and 3 or 4 inches of earth put in. Slight freezing does not injure cabbage, but it should not be subjected to repeated freezing and thawing.

Parsnips will occupy the ground from early spring until fall. The seeds should be sown as early as convenient in the spring in rows 18 inches to 3 feet apart. The plants should later be thinned to stand 3 inches apart in the row. A rich soil with frequent cultivation is necessary for success with this crop. The roots are dug late in the fall and stored in cellars or pits, much as cabbage is, or else are allowed to remain where they are grown and are dug as required for use. All roots not dug during the winter, however, should be removed from the garden, as they will produce seed the second season and become of a weedy nature. When the parsnip has been allowed to run wild in this way the root is considered to be poisonous.

Carrots may be sown early, used during the late summer, and the surplus stored. If desired, a later crop may be sown after the removal of an early vegetable, especially for winter use. Carrots are grown in practically the same way as parsnips, but are not thinned so much and are allowed to grow almost as thickly as planted. They are dug in the autumn and stored in the same manner as parsnips or turnips.

Turnips require a rich soil and may be grown either as an early or late crop. For a late crop it is customary to sow the seeds broadcast on land from which some early crop has been removed. In the North this is generally done during July and August, but the usual time is later in the South. The seed also may be sown in drills 12 to 18 inches apart as for the early crop. After the plants appear they are thinned to about 3 inches.

The rutabaga is similar to the turnip and is grown in much the same way. It requires more space, however, and a longer period for its growth. It is used to a considerable extent for stock feed and has the advantage of being quite hardy.

FRUITS IN THE SMALL GARDEN.

BERRIES.

If there is sufficient space in the home garden, it may be desirable to have it supply fruits as well as vegetables. The small fruits, such as strawberries, raspberries, blackberries, currants, and gooseberries, may be produced with little trouble. A few dozen strawberry plants, and even fewer of the other plants mentioned, should be sufficient for a start. The plantings can be increased from year to year by resetting the young plants which spring up from runners and roots. All the small fruit plants mentioned may be set out in spring. Since most of these plants will occupy the same space year after year, they should be segregated from the part of the garden devoted to annual vegetables.

Grapes may, in many instances, be grown in the home garden more easily than the small bush fruits, since they may be planted near fences and permitted to run upon them. Grape plants also may be set out in spring before the sap rises. Fairly large holes should be dug, and these filled with rich soil mixed with wood ashes.

TREE FRUITS.

Tree fruits probably can not be grown in most small home gardens because of the relatively large areas of soil their roots occupy. The use of dwarf trees, however, makes possible the growing of a few fruit trees in the larger yards and garden inclosures. Though strawberries, cucumbers, and a few other vegetables may be grown near the trees while the latter are small, most vegetables must be grown in the open, where they will receive abundant sunlight. If fruit trees are grown in connection with gardening operations, therefore, they should, where possible, be well removed from the main garden plot.

Apple, peach, cherry, pear, plum, apricot, and quince trees may be purchased on dwarfing stocks. All may be set out in the spring before growth starts. The trees should be set in holes several feet square in which rich soil has been placed. They should be set an inch or so lower than in the nursery.

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THE TOBACCO BUDWORM AND ITS CONTROL

IN THE SOUTHERN TOBACCO DISTRICTS

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FARMERS' BULLETIN 819

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. July, 1917

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Division of Publications, U. S. Department of Agriculture

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BUDWORMS eat holes through the tips of leaves in the developing bud of the tobacco plant, in both open and covered fields, reduce the yield, and render the product practically worthless except for cigar filler and plug filler. The seed also is injured.

The "worms," or larvæ, hatch from eggs laid on the leaves by a greenish moth, and injury begins as soon as they have migrated from the leaves to the bud—usually in about 24 hours.

Control measures, described on pages 6–11 of this bulletin, may be summarized as follows:

Remove from the fields and burn suckers picked from the plants.

Cut and burn plants as soon after harvesting as possible.

Plow as soon as possible after removal of the plants.

When fields are shaded with cheesecloth provide cloth-covered gates and keep them closed, to exclude the budworm moths. Patch promptly all holes in cheesecloth shades.

Destroy plants in seed beds as soon as possible after a sufficient number have been taken for use in the fields.

Cover all seed beds with cheesecloth to exclude the moths.

As soon as plants have become established in the field apply arsenate of lead and corn meal (1 pound of arsenate of lead to 75 pounds of the meal) to the buds. Continue applications twice a week until the plants are topped.

THE TOBACCO BUDWORM[1] AND ITS CONTROL IN THE SOUTHERN TOBACCO DISTRICTS.

CONTENTS.

	Page.		Page.
Description of the insect in its different stages	3	Insect enemies	6
Nature and extent of injury	4	Control measures	6
History and distribution in the United States	4	Poison applications	6
Seasonal history	5	General recommendations	10
Food plants	6		

One of the most important insect pests of tobacco, particularly in the South, is the tobacco budworm (fig. 1). The presence of this pest in tobacco fields, even in very small numbers, may result in great damage to the crop. A thorough knowledge by the planter of the correct methods of control of this insect therefore is essential, especially in areas where the cultivation of tobacco for cigar purposes is practiced.

Since the results of budworm attack on sun-grown and shade-grown tobacco are the same, the control measures outlined herein apply equally to both.

DESCRIPTION OF THE INSECT IN ITS DIFFERENT STAGES.

The tobacco budworm passes through four distinct stages in the course of its development—the egg, larva, pupa, and adult. The eggs are small, whitish, nearly dome-shaped objects, measuring about one-fiftieth of an inch in diameter. They are sculptured with radiating ribs and cross furrows.

The larva, or worm stage (fig. 1, *b*, *c*), is greenish with pale stripes running lengthwise of the body. Small larvæ which have passed through only one or two molts are much lighter in color than those which have fed more extensively and have cast their skins a greater number of times. When first hatched the larva measures about one-twentieth of an inch; when full grown and ready to burrow into the soil for pupation it is about an inch and a half in length.

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[1] *Chloridea virescens* Fab.; order Lepidoptera, family Noctuidae. It was formerly known as *Heliothis rhexiae* S. & A.

The pupa, or quiescent stage (fig. 1, *e*), which is spent in the ground, measures about three-fourths of an inch in length and is brown—almost the color of mahogany.

The adult, or parent (fig. 1, *a*), of the budworm is easily distinguished from other insects found in tobacco fields. It is a greenish moth with a wing spread of about 1½ inches. The forewings are of a beautiful greenish color, obliquely crossed with three lighter lines, and the hind wings are whitish, bordered with a brownish fringe.

NATURE AND EXTENT OF INJURY.

Injury to the plants, which is entirely the work of the larvæ, or worms (fig. 1, *b*, *c*), takes place as soon as the tiny larvæ, hatching from eggs laid on the leaves, reach the bud, although usually it is several days before planters become aware of the damage. The leaves of the bud have then developed somewhat, and examination reveals the presence of the small holes, which have increased in size. When these holes are made in the tips of the leaves in the developing bud, misshapen leaves often result; when the attack is made elsewhere, large unsightly holes develop as the leaf tissue expands. In both cases the leaves are unfit for cigar wrapper and must be placed in the lower grades, often at a loss of as much as $1 a pound. In growing tobacco for cigar purposes it is necessary to produce entire leaves. So complete would be the loss in Georgia and Florida if no control measures were practiced against the budworm that the industry would have to be abandoned. Before the present investigation was begun the budworm was controlled entirely by use of the Paris green and meal mixture. In spite of the use of this insecticide as the means of control, the average loss per acre in shade-grown tobacco was estimated at $37.50. This was due in part to burning by the poison and in part to incomplete control of the insect.

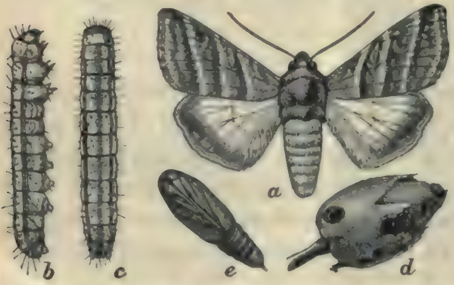

Fig. 1.—The tobacco budworm (*Chloridea virescens*): *a*, Adult, or moth; *b*, *c*, full grown larva, from side and from above; *d*, seed pod bored into by larva; *e*, pupa. Natural size. (Howard.)

HISTORY AND DISTRIBUTION IN THE UNITED STATES.

The tobacco budworm is a very serious pest in the tobacco-growing sections of Florida, Georgia, Alabama, and Louisiana. Although common in North Carolina, South Carolina, and Virginia, it is much less injurious there than in the more southern part of its range. It is rarely injurious in Kentucky and Tennessee. It has been recorded from Missouri, Ohio, and Connecticut. Perhaps the earliest record of injury by this insect dates back to 1797. At that time Smith and Abbot[1] wrote as follows: "[This species] eats the bud and blossoms of Rhexia, as well as of tobacco; to the latter it is very pernicious in Virginia and other places, as it destroys the main shoot."

In Georgia in 1886 it was reported by a planter to have been more injurious to tobacco than the hornworms.[2]

SEASONAL HISTORY.

Eggs and larvæ are present in tobacco fields in Florida and Georgia throughout the growing season. Larvæ have been observed as late as August 1 on plants growing within and around old seed beds.

Eggs are deposited singly on the leaves, usually on the underside. In Florida, during the growing season of tobacco, they hatch in from three to five days. Newly hatched larvæ first feed sparingly on the shells of eggs from which they have issued and then eat small areas about the size of a pinhead from the leaf surface. These minute budworms then begin a migration and reach the bud of the plants in about 24 hours. They often stop to feed two or three times but eat only one or two layers of the leaf cells and do no appreciable injury until they reach the bud.

When the bud is reached the characteristic injury is wrought. The young budworms conceal themselves between the immature, unfolding leaves and begin to feed very greedily. They are so small and so well concealed that they can be detected only by the very closest scrutiny, and if a dose of poison mixture has not been placed in the bud before their arrival extensive injury will have been done before any remedial measure can be made effective.

The larva or worm stage has been found to cover a period of from 18 to 31 days during May and June, at the end of which the mature larvæ burrow into the soil and pupate. The length of the pupa stage may vary during the summer, covering a period of from 13 to 21 days. The emergence of adults from the ground is affected materially by moisture conditions, for it has been observed that a great many moths often appear at the expiration of a dry period.

After the moths emerge a period of from four to five days may elapse before egg laying begins. Moths kept in captivity laid an average of 334 eggs. From observations during May and June of 1916 the average duration of the life cycle was determined to be 37½ days.

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[1] Smith, Sir James Edward. The Natural History of the Rarer Lepidopterous Insects of Georgia. 1797.

[2] *Phlegethontius sexta* Joh. and *P. quinquemaculata* Haw.

FOOD PLANTS.

Besides feeding on tobacco the budworm has been recorded in the United States as attacking deer grass,[1] geranium, and ageratum. It has been reported as feeding upon wild solanaceous plants, including ground cherry[2] and other species of the same genus, and *Solanum seiglinge.*

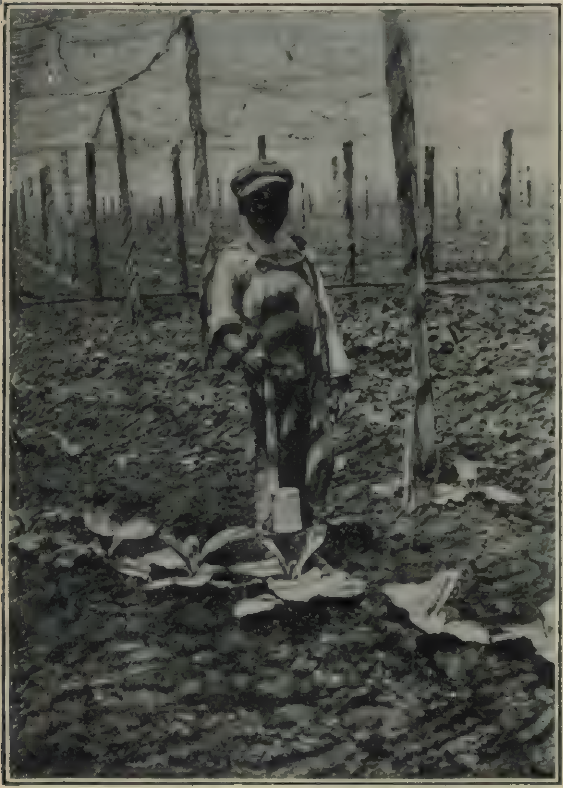

FIG. 2.—Stick and cup method of applying poison mixture in the tobacco bud in combatting the budworm early in the season before the bud leaves have become folded.

INSECT ENEMIES.

Certain wasps have been observed to destroy the larger larvæ, but the most important enemy of the budworm is a small wasplike insect[3] which deposits its eggs in the bodies of the larvæ. This results finally in the death of the budworm. The parasitic insects may be seen continually flying from plant to plant examining the buds in search of budworms. Many farmers mistake these insects for the adult form of the budworm and often destroy them. Having seen the parasites enter the buds and fly away, the planters have examined the buds and, having found the small budworms within, have supposed that they were left there by the parasites.

CONTROL MEASURES.

POISON APPLICATIONS.

It is evident from the habits of the budworm that the most feasible means of direct control are applications of some insecticide in the bud. Experience has shown that at least two applications a week are necessary in order fully to protect the bud, because the poison is scattered by the expansion of the rapidly developing leaves. The first two or three applications are made by means of the stick and cup method (fig. 2). A quart cup with nail holes in the bottom is fastened to a stick and the poison mixture is sifted upon each plant as the operator walks slowly along the row. As the plants increase in size the leaves of the bud are more tightly folded and it becomes necessary to change the method of application by opening the bud with one hand and at the same time dropping a small portion of the poison mixture into the bud with the other hand. The poison is carried in a sack fastened around the waist. (See illustration on title page.)

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[1] *Rhexia virginica.* [2] *Physalis viscosa.* [3] *Toxoneura* sp.

OBJECTIONS TO THE USE OF PARIS GREEN.

The insecticide in use in Florida at the time of the institution of experiments by the Bureau of Entomology was a mixture of 1 pound of Paris green to 150 pounds of corn meal. About 12 to 14 pounds per acre of this mixture is necessary for each application. The applications must be continued from the time tobacco is set until it is topped.

Shade-grown tobacco is very tender and very susceptible to injury from either a mechanical or a chemical source. In dry weather Paris green causes very little damage, but in wet weather considerable injury may result from the comparatively excessive amounts that wash down and collect in the bud and in the axils of the leaves. Planters are familiar with this condition and attempt to avoid injury by making lighter applications. When such a course is adopted some of the poison injury is eliminated but extra damage from budworm attack follows on account of the insufficient dosage. When Paris green mixture is used there is always the possibility of damage either from the action of the poison on the leaves or from budworm attack following the application of insufficient quantities of the mixture. The normal injury also is increased frequently because some laborers apply more of the mixture than is necessary for budworm control.

RELATIVE EFFICIENCY AND ECONOMY IN THE USE OF VARIOUS POISONS.

Owing to this danger of injury to the leaves by Paris green when used in sufficient amounts, and the imperfect protection afforded by smaller quantities, the discovery of a poison that would be safer under all conditions of weather and of application, and one that would, at the same time, give the greatest budworm control was much to be desired. During the seasons from 1913 to 1916, inclusive, experiments were performed with at least 30 mixtures, including the following poisons, some of which have been used more or less commonly against the budworm: Arsenate of lead, antimony sulphid, Paris green, tri-potassium arsenate, ortho-arsenite of zinc, antimony arsenate, and antimony oxid. These were tested in varying strengths and in combination with corn meal, gypsum, and fuller's earth as carriers. Of all the poisons used, Paris green, arsenate of lead, and golden antimony sulphid gave the most promising results, although there is a great variation in the efficiency and cost of application of these poisons. Corn meal was found to be the most satisfactory carrier.

Table 1 indicates the relative average cost per acre per season of antimony sulphid, arsenate of lead, and Paris green, as well as the percentage of leaves free of budworm and poison injury. The cost data are based upon results obtained on 51 plantations where 476 acres of tobacco were treated throughout the season. It was found that an average of 4.17 bushels of meal were necessary to the treatment of 1 acre. In calculating the total cost for the treatment of an acre, corn meal was valued at $1 per bushel. The prices per pound of antimony sulphid, arsenate of lead, and Paris green were taken as 35 cents, 25 cents, and 30 cents, respectively.

TABLE 1.—*Relative efficiency and economy of antimony sulphid, arsenate of lead, and Paris green in controlling the tobacco budworm.*

Poison used.	Cost of poison.	Cost of meal.	Cost of labor.	Total cost per acre per season.	Per cent of leaves free of budworm and poison injury.
Antimony sulphid, 1 pound; corn meal, 24 pounds..	$2.92	$4.17	$2.25	$9.34	98.35
Arsenate of lead, 1 pound; corn meal, 75 pounds.....	.66	4.17	2.25	7.08	98.25
Paris green, 1 pound; corn meal, 150 pounds.........	.40	4.17	2.25	6.82	92.50

From the foregoing table it will be seen that where antimony sulphid had been used at the rate of 1 pound to 24 pounds of corn meal, 98.35 per cent of the leaves were free from budworm and poison injury; and that where arsenate of lead had been used at the rate of 1 pound to 75 pounds of corn meal, 98.25 per cent of the leaves were perfect. The cost of the applications of antimony sulphid per acre per season was $2.26 more than for the arsenate of lead, and of course the difference of one-tenth of 1 per cent in the efficiency of these applications in favor of the antimony sulphid would not compensate for the extra expense.

Where Paris green had been used at the rate of 1 pound to 150 pounds of corn meal, 92.5 per cent of the leaves were free from injury—5.75 per cent less than where arsenate of lead had been applied—but the cost of application per acre per season was 26 cents less than for the arsenate of lead. Since the injury following the use of Paris green has been shown to result in a loss of $37.50 per acre, and arsenate of lead has been shown to save $28.75 of this amount, the actual saving due to the use of arsenate of lead is $28.75 minus 26 cents (for arsenate of lead costs 26 cents per acre more than does Paris green), or $28.49. It will be understood, therefore, that the possibility of incurring a loss of $37.50 per acre will not justify the use of Paris green to effect a saving in material of 26 cents per acre.

A mixture of 1 pound of arsenate of lead and 75 pounds of corn meal has proved to be the most efficient combination against budworms. As already stated, on account of the method of application necessary in controlling budworms, there must be some variation in the quantity applied to each bud. The arsenate of lead and corn meal mixture can be employed without fear of injury in case too great a quantity is used.

Poisons mixed with corn meal are more readily fed upon by budworms than those mixed with other carriers. Then, too, corn meal is the most desirable material for this purpose because it does not interfere with the development of the immature leaves. Even when saturated during periods of showers, corn meal does not become compact and cause damage such as takes place when other carriers are used.

Tests have shown also that the efficiency of arsenate of lead when employed against the budworm varies with the carrier with which it is used, as indicated in Table 2.

TABLE 2.—*Relative efficicncy against the tobacco budworm of arsenate of lead with different carriers.*

Poison.	Experiment No.	Budworm injury.
		Per cent.
Arsenate of lead, 1 pound; corn meal, 75 pounds	1	0.79
Arsenate of lead, 1 pound; gypsum, 25 pounds	2	3.00
Arsenate of lead, 1 pound; Fuller's earth, 16 pounds	3	2.50

In experiment No. 1 arsenate of lead was used at the rate of 1 pound to 75 pounds of corn meal and only 0.79 per cent of leaves showed injury. In experiment No. 2 the arsenate of lead was used three times as strong as in experiment No. 1 (1 pound to 25 pounds) but with gypsum as a carrier. Three per cent of the leaves were injured—nearly four times as many as in experiment No. 1. In experiment No. 3 the arsenate of lead was used nearly five times as strong as in experiment No. 1, yet the leaf injury amounted to 2.5 per cent—more than three times that in experiment No. 1. These experiments indicate that of the three carriers corn meal is preferable in budworm control.

GENERAL RECOMMENDATIONS.

Suckers on plants usually become infested with budworms. When these are removed no care is taken to destroy the infesting larvæ. In one case where suckers were being removed and thrown between the rows 55 per cent were found to be infested. Many of these larvæ may develop to pupæ and later to moths. Suckers should be taken from the fields and burned.

At the end of the growing season tobacco plants from which the marketable leaves have been removed are often allowed to remain standing in the fields. These provide breeding places for the budworms. As soon as possible after harvesting is completed plants should be cut and burned, to destroy the larvæ and pupæ infesting them. This practice has been adopted by some planters who use the ash to good advantage for fertilizer ingredients.

Where tobacco is grown under cheesecloth, preventive measures against budworm attack may be practiced with a great deal of success. In such cases care should be taken to patch holes in the cloth. Since it is necessary to provide openings in these shades through which workmen with farm animals and implements may come and go, gates covered with cheesecloth should be provided, and kept closed as much as possible so as to exclude the moths, or adults, of the budworm.

Plants frequently are left growing within and around old seed beds. These invariably are infested and contribute considerably to the abundance of moths which deposit eggs on plants within the fields. Plants about the seed bed should be destroyed therefore as soon as the seed bed is abandoned.

Seed beds should always be covered and walled in with cloth so as to prevent the entrance of moths. In this way the number of eggs introduced into the fields on the plants will be held to a minimum.

Because of the nature of attack of this tobacco pest much care is necessary in direct-control practices. Experience has shown that a slight delay in making poison applications often results in great damage to the crop. The necessity of applying the mixture directly to the leaves of the bud can not be too greatly emphasized. The effects of careless manipulation may be almost as bad as if no control measures were attempted. Planters should keep these points clearly in mind because the difference between a valuable tobacco crop and one of less than ordinary quality is often dependent upon the care with which budworm control is practiced.

Direct control in Florida and Georgia should begin as soon as possible after the plants have become established in the field. Applications of the poison mixture should be made in the buds from then until the plants have been topped. It is of special importance to emphasize the necessity of beginning the applications of the poison mixture as soon as the plants are set in the field. A delay in starting this work may give time for the eggs that are introduced from the seed beds to hatch, and for the young larvæ (young budworms) to reach the bud and do considerable damage. For the best results the buds must be treated twice a week until topping has been completed.

The best mixture which has been employed in experiments under actual field conditions is 1 pound of arsenate of lead and 75 pounds of corn meal. In the preparation of this mixture care should be taken to obtain an even distribution of the poison throughout the corn meal. For this purpose mechanical mixers have been employed where great quantities are necessary. These, however, are not essential, for with a little extra care the mixtures can be prepared quite as well by hand.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO TOBACCO.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Arsenate of Lead as an Insecticide Against the Tobacco Hornworms in the Dark-tobacco District. (Farmers' Bulletin 595.)
The Tobacco Beetle and how to Prevent Loss from It. (Farmers' Bulletin 846.)
Tobacco Splitworm. (Department Bulletin 59.)
Methods of Controlling Tobacco Insects. (Entomology Circular 123.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

So-called Tobacco Wireworm in Virginia. (Department Bulletin 78.) 1914. Price, 5 cents.
Tobacco Thrips and Remedies to Prevent "White Veins" in Wrapper Tobacco. (Entomology Circular 68.) 1906. Price, 5 cents.
Tobacco Thrips, a New and Destructive Enemy of Shade-grown Tobacco. (Entomology Bulletin 65.) 1907. Price, 5 cents.
Principal Insects Affecting Tobacco Plant. (Farmers' Bulletin 120.) 1900. Price, 5 cents.

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SWEET CLOVER: UTILIZATION

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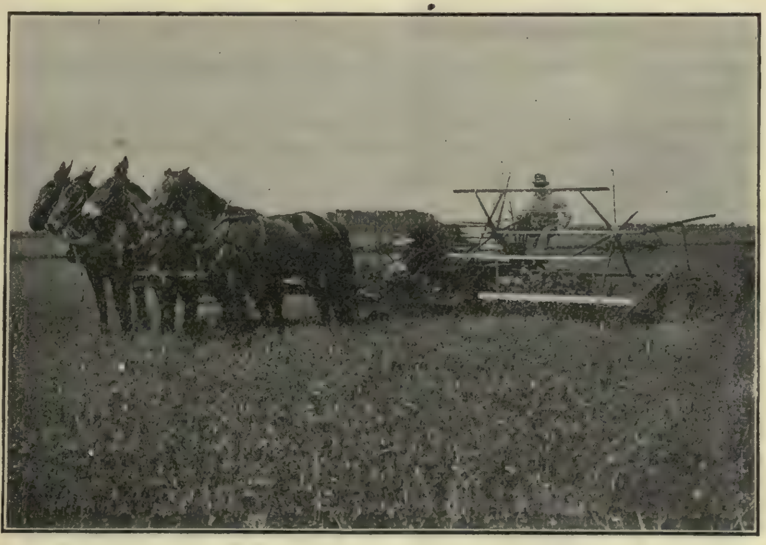

FARMERS' BULLETIN 820

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. May, 1917

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

SWEET CLOVER may be utilized for feeding purposes, as pasturage, hay, or ensilage. With the possible exception of alfalfa on fertile soil, sweet clover, when properly handled, will furnish as much nutritious pasturage from early spring until late fall as any other legume. It seldom causes bloat.

Stock may refuse to eat sweet clover at first, but this distaste can be overcome by keeping them on a field of young plants for a few days.

As cattle crave dry roughage when pasturing on sweet clover, they should have access to it. Straw answers this purpose very well.

An acre of sweet clover ordinarily will support 20 to 30 shotes.

On account of the succulent growth, it is often difficult, in humid climates, to cure the first crop of the second season into a good quality of hay.

When seeded without a nurse crop, one cutting of hay may be obtained the first year in the North and two or three cuttings in the South. Two cuttings are often obtained in the South after grain harvest. The second year a cutting of hay and a seed crop usually are harvested.

Sweet clover should never be permitted to show flower buds before it is cut for hay. It is very important that the first crop of the second season be cut so high that a new growth will develop. When the plants have made a growth of 36 to 40 inches it may be necessary to leave the stubble 10 to 12 inches high.

In cutting the first crop of the second season it is a good plan to have extension shoe soles made for the mower, so that a high stubble may be left. In some sections of the country sweet clover as a silage plant is gaining in favor rapidly.

This crop has given excellent results as a feed for cattle and sheep. Experiments show that it compares favorably with alfalfa.

Sweet clover has proved to be a profitable soil-improving crop. The large, deep roots add much humus to the soil and improve the aeration and drainage. As a rule, the yield of crops following sweet clover is increased materially.

Being a biennial, this crop lends itself readily to short rotations.

Sweet clover is a valuable honey plant, in that in all sections of the country it secretes an abundance of nectar.

This bulletin discusses only the utilization of sweet clover. A discussion of the growing of the crop may be found in Farmers' Bulletin 797.

SWEET CLOVER: UTILIZATION.[1]

CONTENTS.

	Page.
General statement of the uses of sweet clover	3
Sweet clover as a pasture crop	4
Sweet-clover hay	10
Sweet clover as a silage crop	20
Sweet clover as a soiling crop	22
Sweet clover as a feed	23
Sweet clover as a soil-improving crop	28
Sweet clover in rotations	31
Sweet clover as a honey plant	32

GENERAL STATEMENT OF THE USES OF SWEET CLOVER.

The utilization of sweet clover as a feed for all classes of live stock has increased rapidly in many parts of the country, owing primarily to the excellent results obtained by many farmers who have used this plant for pasturage or hay, and also to the fact that feeding and digestion experiments conducted by agricultural experiment stations show that it is practically equal to alfalfa and red clover as a feed.

As a pasture plant, sweet clover is superior to red clover, and possibly alfalfa, as it seldom causes bloat, will grow on poor soils, and is drought resistant. The favorable results obtained from the utilization of this crop for pasturage have done much to promote its culture in many parts of the United States. On account of the succulent, somewhat stemmy growth of the first crop the second year, difficulty is often experienced in curing the hay in humid sections, as it is necessary to cut it at a time when weather conditions are likely to be unfavorable. When properly cured the hay is relished by stock.

At the present time sweet clover is used to only a limited extent for silage, but its use for this purpose should increase rapidly, as the results thus far obtained have been very satisfactory.

In addition to the value of sweet clover as a feed, it is one of the best soil-improving crops adapted to short rotations which can be grown. When cut for hay, the stubble and roots remain in the soil, and when pastured, the uneaten parts of the plants, as well as the manure made while animals are on pasture, are added to the soil and benefit the succeeding crops. In addition to humus, sweet clover, in common with all legumes, adds nitrogen to the soil. This crop is grown in many sections of the country primarily to improve soils, and the benefits derived from it when handled in this manner have justified its use, as the yields of succeeding crops usually are increased materially.

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[1] The growing of this crop has been discussed in a previous publication, Farmers' Bulletin 797, entitled "Sweet Clover: Growing the Crop."

The different species of sweet clover are excellent honey plants, as they produce nectar over a long period in all sections of the United States.

SWEET CLOVER AS A PASTURE CROP.

With the possible exception of alfalfa on fertile soils, no other leguminous crop will furnish as much nutritious pasturage from early spring until late fall as sweet clover when it is properly handled. Live stock which have never been fed sweet clover may refuse to eat it at first, but this distaste is easily overcome by turning them on the pasture in the spring, as soon as the plants start growth (fig. 1). Many cases are on record where stock have preferred sweet clover to other forage plants. The fact that it may be pastured earlier in the spring than many forage plants and that it thrives throughout the hot summer months makes it a valuable addition to the pastures on many farms. Sweet clover is an especially valuable forage plant for poor soils where other crops make but little growth, and it is upon such soils that thousands of acres of this crop are furnishing annually abundant pasturage for all kinds of live stock. In many portions of the Middle West, where the conditions are similar to those of southeastern Kansas, it bids fair to solve the serious pasturage problems. Native pastures which will no longer provide more than a scant living for a mature steer on 4 or 5 acres, when properly seeded to sweet clover will produce sufficient

FIG. 1.—Cattle pasturing on sweet clover.

forage to carry at least one animal to the acre throughout the season. In addition to this, a crop of hay or a seed crop may be harvested from a portion of the land when it is so fenced that the stock may be confined to certain parts of the field at specific times. Land which is too rough or too depleted for cultivation, or permanent pastures which have become thin and weedy, may be improved greatly by drilling in, after disking, a few pounds of sweet-clover seed per acre. Not only will the sweet clover add considerably to the quality and quantity of the pasturage but the growth of the grasses will be improved by the addition of large quantities of humus and nitrogen to the soil.

Sweet clover has proved to be an excellent pasture crop on many of the best farms in the North-Central States. In this part of the country it may be seeded alone and pastured from the middle or latter part of June until frost, or it may be sown with grain and pastured after harvest.

When sweet clover has been seeded two years in succession on separate fields, the field sown the first year may be pastured until the middle of June, when the stock should be turned on the spring seeding. When handled in this manner excellent pasturage is provided throughout the summer, and a hay or seed crop may be harvested from the field seeded the previous season.

Some of the best pastures in Iowa consist of a mixture of Kentucky bluegrass, timothy, and sweet clover. On a farm observed near Delmar, Iowa, stock is pastured on meadows containing this mixture from the first part of April to the middle of June. From this time until the first part of September the stock is kept on one-half to two-thirds the total pasture acreage. The remainder of the pasture land is permitted to mature a seed crop. After the seed crop is harvested the stock again is turned on this acreage, where they feed on the grasses and first-year sweet-clover plants until cold weather. The seed which shatters when the crop is cut is usually sufficient to reseed the pastures. By handling his pasture land in this manner, the owner of the farm has always had an abundance of pasture and at the same time has obtained each year a crop of 2 to 4 bushels of recleaned seed to the acre from one-third to one-half of his pasture land. This system has been in operation on one field for 20 years and not until the last two years has bluegrass showed a tendency to crowd out the sweet clover. It is essential that sufficient stock be kept on the pastures to keep the plants eaten rather closely, so that at all times there will be an abundance of fresh shoots.

Whenever the first crop of the second year is not needed for hay or silage it can be used for no better purpose than pasturage. In fact, it is better to pasture the fields until the middle of June, as this affords one of the most economical and profitable ways of handling the first crop. In addition to its value for pasture, grazing induces the plants to send out many young shoots close to the ground, so that when the plants are permitted to mature seed a much larger number of stalks are formed than would be the case if the first crop were cut for hay. The hay crop is likely to be cut so close to the ground that the plants will be killed, whereas but little danger of killing the plants arises from close pasturing early in the season. Excellent stands of sweet clover will produce an abundance of pasturage for two to three mature steers per acre from early spring to the middle of June.

Cattle which are pasturing on sweet clover alone crave dry feed. Straw has been found to satisfy this desire and straw or hay should be present in the meadow at all times. After stock are removed from the field it is an excellent plan to go over it with a mower, setting the cutter bar so as to leave the stubble 6 to 8 inches high. This will even up the stand, so that the plants will ripen seed at approximately the same date.

Experiments by many farmers in the Middle West show that sweet clover is an excellent pasture for dairy cattle. When cows are turned on sweet clover from grass pastures the flow of milk is increased and its quality improved. Other conditions being normal, this increase in milk production will continue throughout the summer, as the plants produce an abundance of green forage during the hot, dry months when grass pastures are unproductive. If pastures are handled properly they will carry at least one milk cow to the acre during the summer months.

In many parts of the country sweet clover has proved to be an excellent pasturage crop for hogs. When it is utilized for this purpose it usually is seeded alone and pastured for two seasons. The hogs may be turned on the field the first year as soon as the plants have made a 6-inch growth. From this time until late fall an abundance of forage is produced, as pasturing induces the plants to send out many tender, succulent branches. Pasturing the second season may begin as soon as growth starts in the spring. If the field is not closely grazed the second season it is advisable to clip it occasionally, leaving an 8-inch stubble, so as to produce a more succulent growth.

An acre of sweet-clover pasture ordinarily will support 20 to 30 shotes in addition to furnishing a light cutting of hay (fig. 2). For the best growth of the hogs, they should be fed each day 2 pounds of grain per hundredweight of the stock. Hogs are very fond of sweet-clover roots and should be ringed before being turned on the pasture. The tendency to root may generally be overcome by adding some protein to the grain ration. Meat meal serves this purpose very well.

The Iowa Agricultural Experiment Station conducted an interesting pasturing experiment with spring pigs in 1910. In this experiment, pigs weighing approximately 38 pounds each were pastured for a period of 141 days on two plats of red clover, a plat of Dwarf Essex rape, and a plat of yellow biennial sweet clover. The pigs pasturing on each plat received a ration of ear corn. The ration given to the pigs on one plat of red clover and on that of rape was supplemented with meat meal to the extent of one-tenth of the ear-corn ration. The feed given to the pigs pasturing on sweet clover was supplemented with meat meal at the same rate during only the last 57 days of the test. The red clover was seeded in 1908 and reseeded in 1909, so that the plat contained a very good stand of plants at least one year old. The sweet clover was seeded in the spring of 1910, while the rape was sown on April 4, 1910, in 24-inch rows. The pigs were turned on the forage plats on June 22.

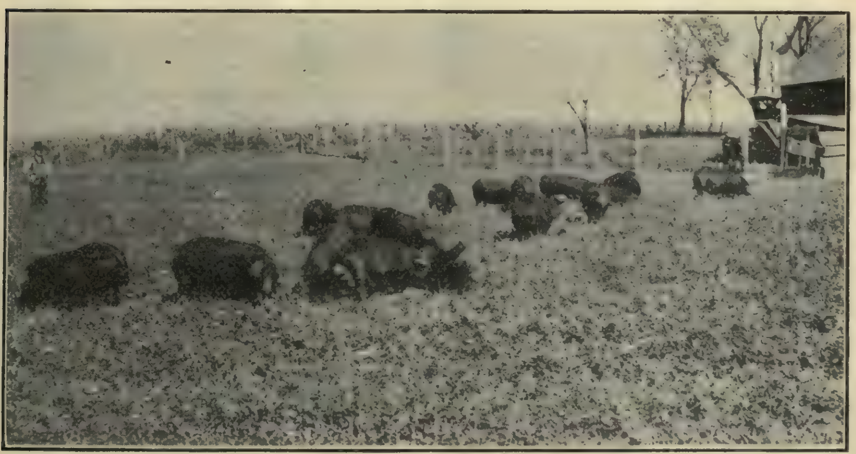

FIG. 2.—Hogs pasturing on sweet clover.

The results of this experiment, as presented in Table I, show that sweet clover carried more pigs to the acre and produced cheaper gains and a greater net profit per acre than either red clover or rape. To judge from the date of seeding of the plants tested, it was to be expected that the pigs pasturing on the sweet clover would not gain as rapidly at first as those pasturing on the other forage plants, as the growth of the sweet clover at this time was undoubtedly much less than that of the other crops. This assumption is borne out by the results given for the first 84 days of the test. During this period the pigs on the rape made a net gain of $11.55 per acre and those on the red clover $6.86 per acre more than those on the sweet clover. In these computations corn was valued at 50 cents per bushel and hogs at $6 per hundredweight. During the latter part of the experiment there was but a scant growth of red clover on the plats, while the sweet clover produced an abundance of forage, and during this period of the experiment the pigs pasturing on sweet clover made a net gain of $16.14 per acre more than those pasturing on red clover and $17.41 per acre more than those pasturing on rape. (Table I.) The difference in net profits probably would have been greater had white sweet clover been used instead of yellow sweet clover, as it makes a larger growth and contains approximately the same ratio of food elements.

TABLE I.—*Relative merits of Dwarf Essex rape, red clover, and yellow sweet clover when pastured by spring pigs for 141 days, June 22 to November 10, 1910.*

Forage tested, plat area, and ration.	Number of hogs.	Initial weight per hog.	Total gain, all hogs.	Average daily gain per hog.	Supplementary feed required for 100 pounds of gain.		Total cost of 100 pounds of gain.[1]	Net profit per acre.[2]
					Shelled corn.	Meat meal.		
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*		
Rape (Dwarf Essex, 0.9 acre) and ear corn[3] plus one-tenth meat meal.	18	37.8	2,801.7	1.10	292.5	33.99	$3.79	
Reduced to acre basis	20		3,113.0					$68.64
Clover (medium red, 0.8 acre) and ear corn alone[3]	15	39.0	1,790.0	.84	370.6	None.	3.71	
Reduced to acre basis	18.75		2,237.5					51.20
Clover (medium red, 0.8 acre) and ear corn[3] plus one-tenth meat meal.	15	39.0	2,394.0	1.13	299.3	34.77	3.84	
Reduced to acre basis	18.75		2,992.5					64.55
Sweet clover[4] (yellow biennial, 0.8 acre) and ear corn[3] plus one-tenth meat meal	18	37.8	2,594.0	1.02	313.6	24.70	3.70	
Reduced to acre basis	22.50		3,242.5					74.50

[1] Corn valued at 50 cents per bushel, meat meal at $2.50 per hundredweight.

[2] Hogs valued at $6 per hundredweight.

[3] During the first 84 days of the test, practically two-thirds of the time, a limited ration of corn was given, while during the last 57 days the pigs received a full feed.

[4] The pigs pasturing on sweet clover received meat meal only during the last 57 days of the experiment.

An experiment reported by the New Jersey Agricultural Experiment Station shows that a mixture of rape and sweet clover makes an exceptionally fine pasture for hogs. In this experiment the mixture of rape and sweet clover produced more pasturage than alfalfa and was preferred to alfalfa by the hogs. It was seeded at the rate of 6 pounds of Dwarf Essex rape and 10 pounds of sweet clover to the acre.

Sheep relish sweet clover and make rapid gains when pastured on it. Care must be taken to see that pastures are not overstocked with sheep, as they are likely to eat the plants so close to the ground as to kill them. This is especially true the first year, before the plants have formed crown buds. Yellow biennial sweet clover probably would not suffer from this cause as much as the white species, because the plants make a more prostrate growth and are not likely to be eaten so closely to the ground.

Horses and mules do well on sweet-clover pastures. On account of the high protein content sweet clover provides excellent pasturage for young stock. No cases of slobbering have been noted with horses.

TAINTING MILK AND BUTTER.

Milk may be tainted occasionally when cows are pasturing on sweet clover. However, the large majority of farmers who pasture sweet clover on an extensive scale report very little or no trouble. The flavor imparted to milk at times is not disliked by all people, as some state that it is agreeable and does not harm the market value of dairy products in the least. This trouble is experienced for the most part in the early spring. The tainting of milk may be avoided by taking the cows off the pasture two hours before milking and keeping them off until after milking the following morning.

BLOATING.

Unlike the true clovers and alfalfa, sweet clover seldom causes bloat; in fact, with the exception of the summer of 1915, only a few authentic cases of bloat have thus far been recorded in sections where large acreages are pastured with cattle and sheep. A number of cases of bloat were reported in Iowa during the abnormally wet season of 1915. No satisfactory explanation for this comparative freedom from bloating has been offered. It is held by some that the coumarin in the plants prevents bloating, but this has not been established experimentally.

TREATMENT FOR BLOAT.

Cattle.—If the case of bloat is not extreme, it may be sufficient to drive the animals at a walk for a quarter or half an hour. In urgent cases the gas must be allowed to escape without delay, and this is best accomplished by the use of the trocar. In selecting the place for using the trocar, the highest point of the distended flank equally distant from the last rib and the point of the hip must be chosen. Here an incision about three-fourths of an inch long should be made with a knife through the skin, and then the sharp point of the trocar, being directed downward, inward, and slightly forward, is thrust into the paunch. The sheath of the trocar should be left in the paunch as long as any gas continues to issue from it. In the absence of a trocar an incision may be made with a small-bladed knife and a quill used to permit the gas to escape. Care must be taken to see that the quill does not work down out of sight into the incision.

Another remedy consists in tying a large bit, the diameter of a pitchfork handle, in the mouth, so that a piece of rubber tubing may be passed through the mouth to the first stomach to allow the gas to escape.

When the animal is not distressed and the swelling of the flank is not great, or when the most distressing condition has been removed by the use of the trocar, it is best to administer internal medicine. Two ounces of aromatic spirits of ammonia should be given every half hour in a quart of cold water, or half an ounce of chlorid of lime may be dissolved in a pint of tepid water and the dose repeated every half hour until the bloating has subsided.[1]

For acute bloating the Kentucky Agricultural Experiment Station recommends 1 quart of a 1½ per cent solution of formalin, followed by placing a wooden block in the animal's mouth and by gentle exercise if the animal can be gotten up.

Sheep.—Gas may be removed quickly from bloated sheep by using a small trocar. The seat of the operation is on the most prominent portion of the left flank.

SWEET-CLOVER HAY.

When sweet-clover hay is cut at the right time and cured properly it is eaten readily by all classes of live stock. As the hay is rich in protein, growing stock make gains on it comparable to the gains of those fed on alfalfa. The quantity and quality of the milk produced when the hay is fed to cows are approximately the same as when other legumes are used. Hay which is cut the first year is fine stemmed and leafy and resembles alfalfa in general appearance. Unless it is cut at the proper time the second year, it will be stemmy and unpalatable. Feeding experiments show that it contains practically as much digestible protein as alfalfa and more than red clover, but the hay is not as palatable as red clover or alfalfa when the plants are permitted to become coarse and woody. When sweet clover is seeded in the spring without a nurse crop in the northern and western sections of the United States, a cutting of hay may be obtained the same autumn. When it is seeded with a nurse crop in these regions, the rainfall during the late summer and early fall will largely determine whether the plants will make sufficient growth to be cut for hay. On fertile, well-limed soils in the East, in the eastern North-Central States, in Iowa, and in eastern Kansas a cutting of hay is commonly obtained after grain harvest when the rainfall is normal or above normal. In many sections of the country two, and at times three, cuttings of hay may be obtained the second year (fig. 3).

In the South two, and sometimes three, cuttings may be obtained the first year if the seeding is done without a nurse crop. When the seed is sown in the spring with oats, two cuttings may be secured after oat harvest. Three cuttings may be obtained the second year, although it is the common practice to cut the first crop for hay and the second crop for seed.

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[1] See "Diseases of Cattle," a special report of the Bureau of Animal Industry.

YIELDS OF SWEET-CLOVER HAY.

The total yields of sweet clover per acre for the season are usually less than those of alfalfa except in the semiarid unirrigated portions of the country. Sweet clover ordinarily yields more to the acre than any of the true clovers.

When the seed is sown in the spring in the North without a nurse crop, yields of 1 to 3 tons of hay of good quality may be expected the following autumn. The Massachusetts Agricultural Experiment Station obtained 2,700 pounds of hay per acre in the fall from spring seeding, while the United States Department of Agriculture obtained 3,000 pounds of hay per acre in August from May seeding in Maryland. Yields of 1 to 2 tons, and occasionally 3 tons, have been obtained in Michigan, Illinois, Iowa, Kansas, the Dakotas, and other States. In Illinois, Iowa, and Kansas yields of 1 to 1½ tons are often obtained after grain harvest when weather conditions are favorable.

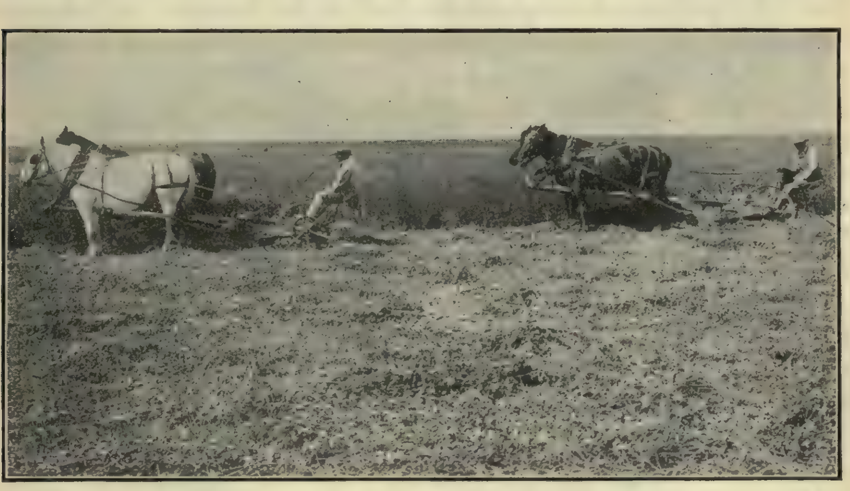

FIG. 3.—Cutting sweet clover for hay in western Kansas.

The first crop the second season yields 1½ to 3 tons of hay to the acre in the northern and western sections of the United States. The second crop of the second season will yield from three-fourths to 1½ tons to the acre, although this crop usually is cut for seed.

When sweet clover is seeded in the South without a nurse crop on fairly fertile soil that is not acid, three cuttings of hay, averaging at least a ton to the cutting, may be secured the year of seeding. When the seed is sown in the early spring on winter grain, two cuttings, yielding at least 1 ton to the cutting, may be obtained. The first crop the second season yields on an average 1½ to 3 tons of hay to the acre. In 1903 the Alabama Canebrake Station obtained 2½ tons of hay after oat harvest and a total yield of 3 tons per acre from the same field in 1904.

TIME TO CUT SWEET CLOVER FOR HAY.

The first season's growth of sweet clover does not usually get coarse and woody and therefore may be cut when it shows its maximum growth in the fall. In regions where more than one crop may be obtained the first season, the first crop should be cut when the plants have made about a 30-inch growth.

The proper time to cut the first crop the second season will vary considerably in different localities, depending very much upon the rainfall, the temperature, and the fertility of the soil. In no event should the plants be permitted to show flower buds or to become woody. In the semiarid sections of the country sweet clover does not grow as rapidly as in more humid regions. Neither do the plants grow as rapidly on poor soils as upon fertile soils. In the drier sections the best results usually are obtained by cutting the first crop when the plants have made a growth of 24 to 30 inches. On fertile, well-limed soils in many sections of the country a very rapid growth is made in the spring, and often the plants will not show flower buds until they are about 5 feet high. On such soils it is very essential that the first crop be cut when the plants have made no more growth than 30 to 32 inches if hay is desired which is not stemmy and if a second growth is to be expected.

HEIGHT OF STUBBLE TO BE LEFT WHEN CUTTING FOR HAY.

It is not necessary to leave more than an ordinary stubble when cutting the sweet-clover hay crop in the fall of the year of seeding. A stubble 4 or 5 inches in height, however, will serve to hold drifting snow and undoubtedly will be of some help in protecting the plants from winter injury. While sweet clover without question is more hardy than red clover, usually more or less winterkilling occurs, and any protection which may be afforded during cold weather will be of considerable benefit.

While the first crop in the second year comes from the crown buds, the new branches which produce the second crop of the second year come from the buds formed in the axils of the leaves on the lower portions of the stalks which constitute the first crop, as shown in figure 4. These branches usually commence growth when the plants are about 24 inches high. In fields where the stand is heavy and where the lower portions of the plants are densely shaded, these shoots are soon killed from lack of necessary light. (Figs. 4 and 5.) The branches which are first to appear and which are first to be killed are those closest to the ground. It is therefore very important when cutting this crop to cut the plants high enough from the ground to leave on the stubble a sufficient number of buds and young branches to produce a second crop.

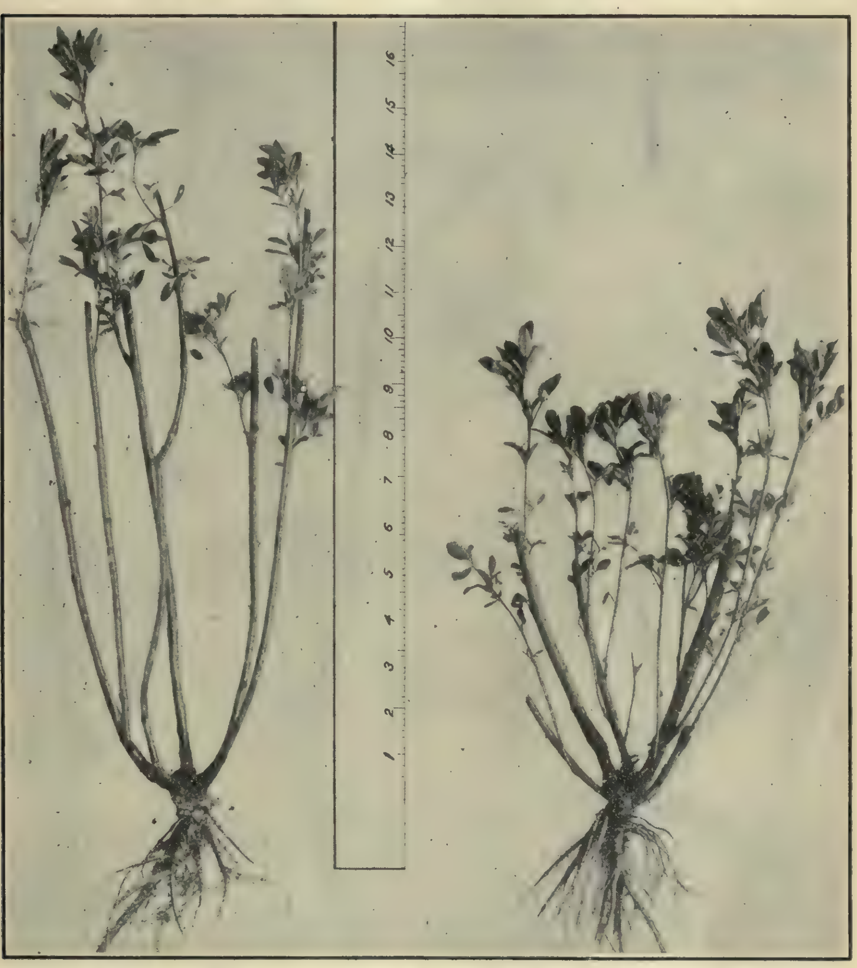

FIG. 4.—Sweet-clover plants, showing the direct relation that exists between the thickness of stand, the time of cutting, and the height at which the stubble must be cut if a second crop is to be expected. The plant at the left was cut 10 days later than the plant at the right. Note the height at which it was necessary to cut this plant so that a second crop would develop and also the scars on the stubble where young shoots had started earlier and were killed from lack of sunlight. When the stand is thin the young shoots will survive, as they did on the plant at the right, even though the field is cut at a later date.

Examination of hundreds of acres of sweet clover in different sections of the United States during the summers of 1915 and 1916 showed that the stand on at least 50 per cent of the fields was partly or entirely killed by cutting the first crop the second season too close to the ground. A direct relation exists between the thickness of the stand, the height of the plants, and the height at which the stubble should be cut if a second crop is to be harvested. It is very essential to examine the fields carefully before mowing, so as to determine the height at which the plants should be cut in order to leave at least one healthy bud or young branch on each stub. In fact, the stand should be cut several inches above the young shoots or buds, as the stubble may die back from 1 to 3 inches if the plants are cut during damp or rainy weather.

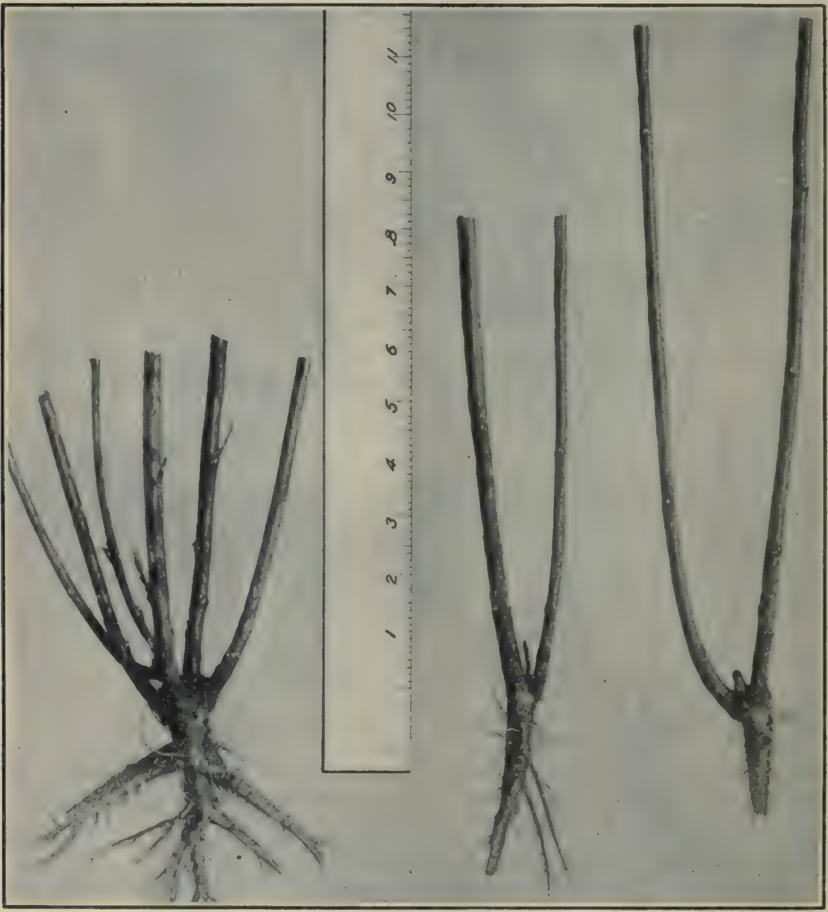

FIG. 5.—Stubble of sweet clover collected in fields where 90 per cent of the plants had been killed by cutting too closely to the ground. The heavy stands in these fields were not cut until the plants had made a growth of 36 to 40 inches. Note the scars on the stubble where young shoots started, but died from lack of light.

When fields of sweet clover contain only a medium-heavy stand and when the plants have made no more than a 30-inch growth, a 5 to 6 inch stubble usually will be sufficient to insure a second crop, but where fields contain heavy stands—15 to 25 plants to the square foot—it may be necessary to leave an 8-inch stubble. In many fields examined in northern Illinois in June, 1916, heavy stands had been permitted to make a growth of 36 to 40 inches before cutting. In a number of these fields a very large percentage of the plants were killed when an 8 to 12 inch stubble was left. (See fig. 5.) A careful examination of such fields showed that the young branches had started on the lower portions of the stalks and had died from lack of light before cutting. In semiarid regions, where the plants do not make as rapid growth as in humid sections, they may, as a rule, be clipped somewhat closer to the ground without injury.

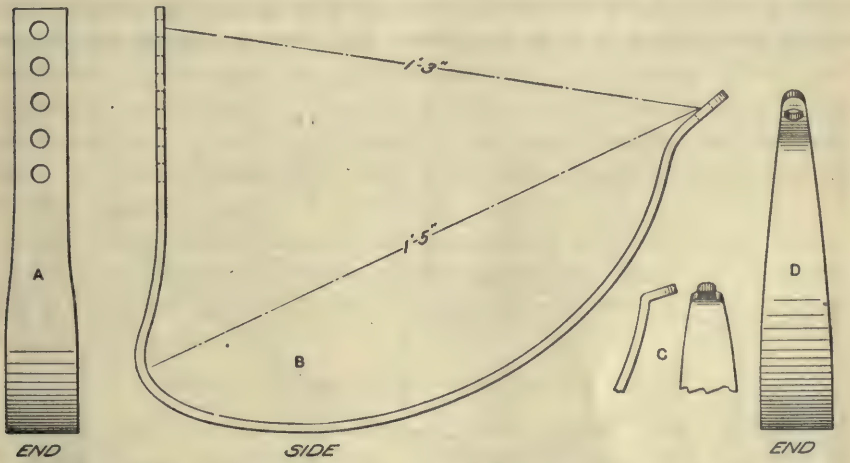

FIG. 6.—Shoe sole to be placed on the inner shoe of the mower, so that a high stubble may be left when mowing sweet clover: *A*, End view of the back part of the sole; *B*, side view of the sole, showing general shape; *C*, shape of the front end of the sole when it is to be used on mowers having shoes of the type used on Deering machines; *D*, forward end of the sole represented in *B*. The forward end of the sole shown in *B* and *D* should be made for machines having shoes of the type used on McCormick mowers.

On account of the difference in the growth that sweet clover makes on different types of soil and on account of the difference in the thickness of the stand obtained in different fields, it is impossible to give any definite rule as to the proper height to cut the first crop.

MOWER CHANGES FOR CUTTING SWEET CLOVER.

It is good practice to replace the shoe soles of the mower with higher adjustable soles, so that a stubble up to 12 inches in height may be left when cutting sweet clover. Shoe soles such as are shown in figures 6 and 7 may be made on any farm provided with a blacksmith's forge, or they can be made at any blacksmith shop at a cost which should not exceed $2.50. Preferably they should be of strap iron, about one-fourth of an inch thick and 2 inches wide; however, old pieces of iron or steel which may be found on the farm will serve the purpose.

When these soles are to be placed on machines that have shoes of the type used on the Deering mower, the forward 8 inches of the sole for the inner shoe should be tapered gradually to a blunt point and bent in such a manner that it will hook into the slot in the shoe. (Fig. 6, *C*.) When the soles are to be placed on mowers having shoes of the type used on McCormick machines, the forward 8 inches of the sole for the inner shoe should be tapered gradually to about 1 inch in width, bent forward so that it will fit against that portion of the shoe where it is to be bolted, and have a hole of the proper size bored for the bolt three-fourths of an inch from the end. (Fig. 6, *B* and *D*.) The bottom of the sole should be rounded, so as to run smoothly on the ground when the cutter bar is raised to cut at different heights. The back portion of the sole should be upright and should have holes bored in it, so that it may be set for the cutter bar to rest at different heights from the ground. Preferably the lower hole of the upright should be located so that when the bolt in the shoe is run through it the cutter bar will be 6 inches from the ground. It should be long enough to permit four or five holes, 1 inch apart, to be bored above the lower one. (Fig. 6, *A*.)

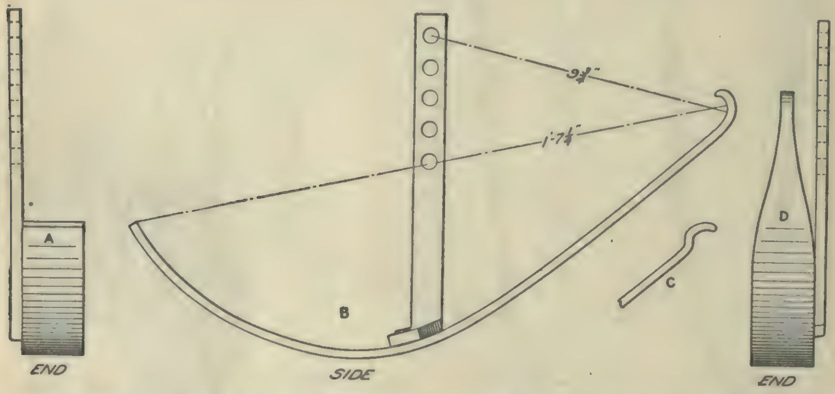

FIG. 7.—Shoe sole to be used on the outer shoe of the mower, so that a high stubble may be left when cutting sweet clover: *A*, End view of the back part of the sole; *B*, side view of the sole, showing general shape; *C*, forward end of the sole to be used on certain Deering machines; *D*, end view of the front part of sole shown in *B*.

With some makes of machines it is not advisable to raise the cutter bar higher than 10 inches from the ground, but when this is true the cutter bar may be tipped upward, so that a 12-inch stubble is left.

The forward end of the shoe sole to be used on the outer shoe should be tapered gradually to 1 inch from the end. The forward inch should be one-fourth of an inch in width and bent slightly upward and inward, so that a hook will be formed to fit into the slot in the front end of the shoe. (Fig. 7, *B*.) The rest of the sole should be curved, so that it will run smoothly on the ground when the cutter bar is set to cut at different heights. The upright which is bolted to the sole should preferably be made of three-eighths by 1 inch material and should have six holes, 1 inch apart, bored in it, so that the outer end of the cutter bar may be raised to the same height as the inner end. On practically all standard makes of mowers the outer shoe sole hooks into the shoe instead of bolting to it, as is the case with the inner sole on some machines. A wheel is used in place of a shoe sole on the outer end of the cutter bar on some machines. When this is the case, the upright to which this wheel is attached should be lengthened. On other machines the forward end of the sole hooks into a slot in the shoe in the same manner as the inner sole. In this event the front end of the sole should be bent slightly upward and outward. (Fig. 7, *C*.)

Before shoe soles are made for any mower a careful examination should be made of the shoes to determine the exact size required and the manner in which they should be attached to the forward ends of the shoes.

CURING AND HANDLING SWEET-CLOVER HAY.

One of the greatest difficulties in curing sweet clover is the fact that the plants usually are ready to be cut for hay at a time of the year when weather conditions are likely to be unfavorable for haymaking. Little trouble is experienced in curing this crop in the drier sections of the country where the methods used for alfalfa are employed. The curing of sweet clover is more difficult than the curing of either red clover or alfalfa, as the leaves are very apt to shatter before the stems are cured. Every possible means should be employed to save the leaves, as these constitute the best part of the hay. (See Table II.)

TABLE II.—*Average analyses of the leaves and stems of four samples of well-cured white sweet-clover hay.*

[Analyses made by the Bureau of Chemistry.]

Samples.	Constituents (per cent).					
	Moisture.	Ash.	Ether extract.	Protein.	Crude fiber.	Nitrogen-free extract.
Leaves	8.70	10.92	3.09	28.20	9.28	39.78
Stems	8.70	8.08	.70	10.16	39.45	33.08

The hay collected for the above analyses represented the first cutting the second season. The plants had made a 30 to 36 inch growth at the time of cutting. It will be seen that the protein content of the leaves is almost three times as great as that of the stems.

In the drier sections of the country or when the first crop of the year of seeding is cut for hay in the North-Central States the mower may be started in the morning as soon as the dew is off. The hay should remain in the swath until the following day, or until it is well wilted, when it should be raked into small windrows. After remaining in the windrows for a day it may be placed in small cocks to cure. Cocks made from hay which has dried to this stage will not shed water well and therefore should be covered if it is likely to rain. It is important that the cocks be made small enough to be thrown on the rack entire, as many leaves will be lost if it is necessary to tear them apart.

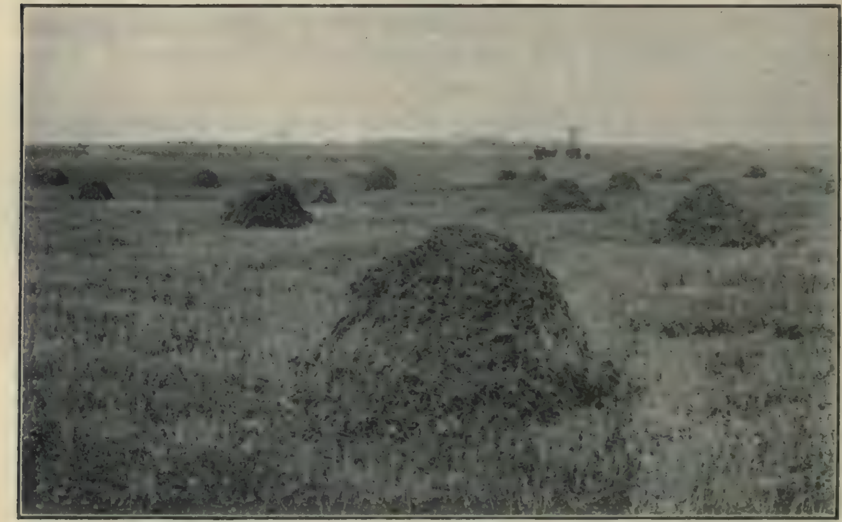

FIG. 8.—Sweet clover curing in the cock.

When sweet clover is permitted to dry in the swath, a large percentage of the leaves will be lost in windrowing and loading unless handled with the utmost care. Hay in this condition should never be raked while perfectly dry and brittle, but should be raked into the windrow in the early morning or in the evening, when it is slightly damp from dew. It may then be hauled to the barn or stack after remaining in the windrow for a day.

One of the most successful methods for handling sweet-clover hay, especially in regions where rains are likely to occur at haying time, is to permit the plants to remain in the swath until they are well wilted or just before the leaves begin to cure. The hay should then be raked into windrows and cocked at once (fig. 8). The cocks should be made as high and as narrow as possible, as this will permit better ventilation. In curing, the cocks will shrink from one-third to one-half of their original size. It may take from 10 days to 2 weeks to cure sweet clover by this method, but when well cured all the leaves will be intact and the hay will have an excellent color and aroma. When sweet clover is cocked at this time the leaves will cure flat and in such a manner that the cocks will readily shed water during heavy rains (fig. 9).

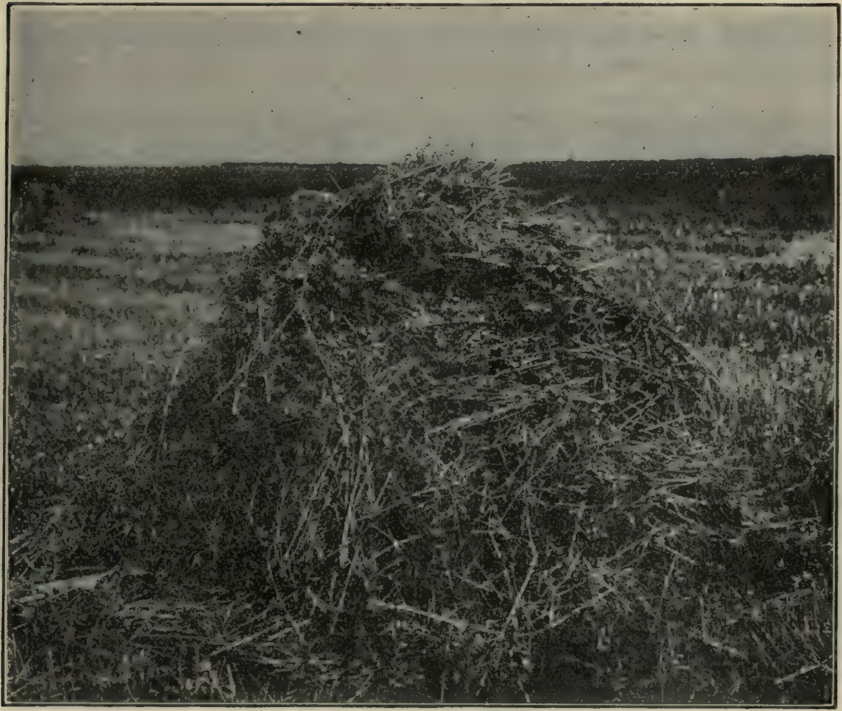

FIG. 9.—A cock of sweet-clover hay which has cured in excellent condition and retained all of its leaves.

When sweet-clover hay is to be stacked it is highly desirable that some sort of foundation be made for the stack, so as to prevent the loss of the hay which otherwise would be on the ground. Several feet of straw or grass are often used for this purpose, but still better is a foundation of rails, posts, or boards placed in such a manner that air may circulate under the stack.

A cover should be provided for the stacks, either in the form of a roof, a canvas, or long green grass. If none of these means is practicable a topping of perfectly green sweet clover will cure with the leaves flat and will turn water nicely.

It is well known that hay made from either red clover or alfalfa will often undergo spontaneous combustion if put into the barn with too much external moisture upon it. No instances of spontaneous combustion in sweet-clover hay have been noted, but this may be due to the fact that comparatively little sweet-clover hay is stored in barns. The same precautions, therefore, should be taken with sweet-clover hay as with red clover or alfalfa.

SWEET CLOVER AS A SILAGE CROP.

In some sections of the country sweet clover is gaining in favor as a silage crop, either alone or in mixtures with other plants. The silage made from this plant will keep better than that made from most legumes, as it does not become slimy, as is so often the case with red clover or alfalfa silage. It produces a palatable feed, which should contain more protein than well-matured corn silage.

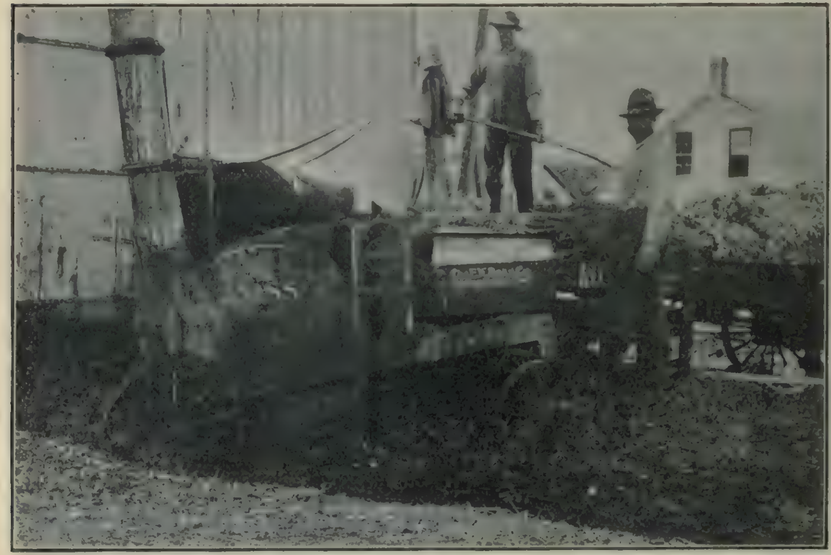

FIG. 10.—Filling the silo with sweet clover.

When sweet clover makes sufficient growth after grain harvest, or when seeded alone, it is not necessary to cut it for silage until fall. At this time it may be run into the silo alone or in mixture with corn. Excellent results have been obtained by placing alternate loads of corn and sweet clover in the silo. (Fig. 10.)

When the first crop the second season is not needed for pasturage, ensiling may prove to be the most economical and profitable way of handling it, as it is necessary to cut this crop for hay at a time of the year when the weather conditions in humid regions are very likely to be unfavorable for haymaking. The large percentage of leaves which usually are lost from shattering when harvesting the hay will be saved when the crop is run into the silo.

The first crop the second season will produce approximately two-thirds as much silage to the acre as corn when it is cut at the time it should be cut for hay. The second crop may then be harvested for seed. When sweet clover is handled in this manner, approximately two-thirds of the total corn acreage which would be cut for silage may be permitted to mature, as the first crop of sweet clover will replace the corn silage, while the seed crop ordinarily will bring as much per acre as the corn. In addition to this, the roots and stubble will add large quantities of vegetable matter to the soil.

Some farmers do not cut sweet clover for silage until it is in full bloom. When this is done, 10 to 12 tons of silage will be obtained per acre, but the plants will be killed by the mowing.

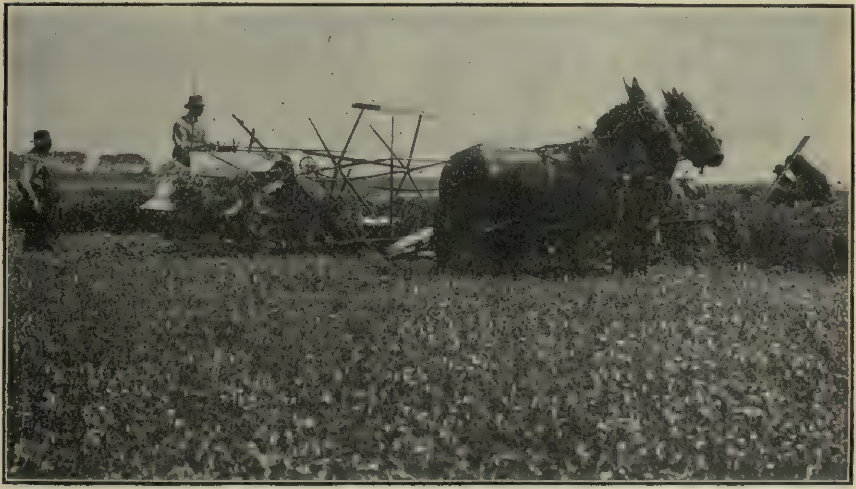

FIG. 11.—Cutting sweet clover with a grain binder for silage.

When the green plants are ensiled, the crop preferably should be cut with a grain binder. (See illustration on title-page and fig. 11.) This will solve the difficulty of cutting a high stubble and will at the same time bind the plants so that they may be run through the silage cutter without difficulty. Green plants, and especially the first crop of the second season, contain too much moisture to be run into the silo immediately after cutting. In some cases quantities of juice have been pressed out of the bottom of the silo, and as a result the silage settled considerably. Analyses of the juice from one silo showed that it contained 0.23 per cent protein and 2 per cent carbohydrates. This loss of juice may be overcome by permitting the bundles to remain in the field just as they come from the binder until the plants are wilted thoroughly. Straw or corn stover may be placed in the bottom of the silo to absorb some of the juice. If the plants contain too much moisture it may be a good plan to mix some corn stover with the sweet clover as it is run into the silo.

Several silos in Illinois have been filled with sweet-clover straw. When this is done it is necessary to add sufficient water to moisten the dry stems. These stems become soft in a short time and ensile in good condition. When the seed crop is thrashed with either a grain separator or a clover huller the stems are broken and crushed sufficiently to render it unnecessary to run them through a silage cutter. Care must be taken when ensiling the straw to add sufficient water, if molding is to be avoided. It will probably be necessary to add water at the blower and also at the top of the silo. It is essential to tramp the straw thoroughly, so as to exclude as much air as possible. After the silo is filled it should be covered with a layer of green plants and thoroughly soaked with water.

Table III gives analyses of several samples of sweet-clover silage as compared to corn silage.

TABLE III.—*Composition of sweet-clover silage and well-matured corn silage.*

Kind of silage.	Number of analyses.	Constituents (per cent).					
		Water.	Ash.	Crude protein.	Carbohydrates.		Fat.
					Fiber.	Nitrogen-free extract.	
White sweet clover:							
First year's growth [1]	1	73.7	1.73	3.17	20.8		0.65
First crop, second season [2]	1	73.7	2.57	2.06	8.08	12.32	1.27
Straw [2]	3	73.7	1.19	2.70	13.59	8.33	.50
Corn, well matured [3]	121	73.7	1.70	2.10	6.30	15.40	.80

[1] Analyzed by the Illinois Agricultural Experiment Station. [2] Analyzed by the Bureau of Chemistry.
[3] Analyses compiled by Henry and Morrison.

As shown in Table III the analyses of the first and second years' growth of sweet clover compare favorably in food elements with corn silage. It is to be expected that the silage made from the sweet-clover straw would contain less protein and carbohydrates than that made from the entire plants, as most of the leaves shatter from sweet clover before the seed crop is cut. Considerable protein and carbohydrates were lost from the silage made from the first crop the second season, as the plants were run into the silo as soon as they were cut. Much juice was pressed from the bottom of this silo. An analysis of this juice is given on page 21.

SWEET CLOVER AS A SOILING CROP.

As a soiling crop sweet clover has been used to only a very limited extent. The average yields of green matter vary from 6 to 15 tons per acre. The season for soiling may commence when the plants are 12 to 15 inches high and continue until flower buds appear. An area of such a size that the plants may be cut every four or five weeks should be selected. The plants should not be cut closer to the ground than 4 inches during the first part of the season and 9 to 12 inches during the latter part of the season. On account of the high protein content and the large amount of forage produced on a relatively small area, sweet clover may profitably be fed in this manner when more desirable soiling crops are not to be had.

SWEET CLOVER AS A FEED.

PALATABILITY OF SWEET CLOVER.

The woody growth of sweet clover as it reaches maturity and the bitter taste due to coumarin have been the principal causes for live stock refusing to eat it at first. On this account many farmers have assumed it to be worthless as a feed. It is a fact that stock seldom eat the hard, woody stems of mature plants, but it is true also that stock eat sparingly of the coarse, fibrous growth of such legumes as red or mammoth clover when they have been permitted to mature and have lost much of their palatability. All kinds of stock will eat green sweet clover before it becomes woody, or hay which has been cut at the proper time and well cured, after they have become accustomed to it. Many cases are on record in which cattle have refused alfalfa or red clover when sweet clover was accessible. Milch cows have been known to refuse a ration of alfalfa hay when given to them for the first time. Western range cattle which have never been fed corn very often refuse to eat corn fodder, or even corn, for a short time, and instances have come under observation in which they ate the dried husks and left the corn uneaten. When these cattle were turned on green grass the following spring they browsed on the dead grass of the preceding season's growth, which, presumably, more closely resembled the grass to which they were accustomed. Such preliminary observations should never be taken as final, even when they represent the results of careful investigators. When cowpeas were first introduced into certain sections of this country much trouble was experienced in getting stock to eat the vines, either when cured into hay or made into ensilage. This difficulty, however, was soon overcome.

It is very true that stock which have never been pastured on sweet clover or fed on the hay must become accustomed to it before they will eat it, but the fact that sweet clover is now being fed to stock in nearly every State indicates that the distaste for it can be overcome easily and successfully. As sweet clover usually starts growth earlier in the spring than other forage plants and as the early growth presumably contains less coumarin than older plants, stock seldom refuse to eat it at this time. Properly cured hay is seldom refused by stock, especially if it is sprinkled with salt water when the animals are salt hungry.

COMPOSITION OF SWEET CLOVER.

Sweet clover, like most legumes, contains a relatively high percentage of protein, thus making it a source of that valuable constituent of feeds needed for growing stock and for the production of milk. Table IV shows the relative composition and digestibility of sweet clover as compared to some other feeds.

TABLE IV.—*Composition and digestibility of sweet clover compared with that of other forage crops.*

AVERAGE PERCENTAGE COMPOSITION OF SWEET CLOVER AND OTHER FORAGE CROPS.

Kinds of forage.	Number of analyses.	Constituents (per cent).					
		Water.	Ash.	Crude protein.	Carbohydrates.		Fat.
					Fiber.	Nitrogen-free extract.	
Green crop:							
Sweet clover[1]	18	75.6	2.1	4.4	7.0	10.2	0.7
Alfalfa[1]	143	74.7	2.4	4.5	7.0	10.4	1.0
Red clover[1]	85	73.8	2.1	4.1	7.3	11.7	1.0
Hay (moisture-free basis):							
White sweet clover [2]	37		8.2	17.6	28.2	43.0	3.0
Yellow sweet clover[2]	3		6.4	15.8	35.6	39.6	2.6
Alfalfa[2]	211		9.6	17.4	29.8	40.3	2.9
Red clover[2]	99		7.9	15.6	27.7	44.9	3.9
Timothy[2]	194		6.2	8.2	32.5	49.9	3.2

DIGESTIBLE NUTRIENTS OF SWEET CLOVER AND OTHER FORAGE CROPS WHEN FED TO SHEEP.[3]

Kinds of forage.	Dry matter in 100 pounds.	Digestible nutrients in 100 pounds of air-dried hay.				Nutritive ratio.[4]
		Protein.	Carbohydrates.	Fat.	Dry matter.	
White sweet-clover hay	92.2	11.88	36.68	0.49	56.12	1:3.2
Pea hay	93.1	11.24	48.55	.71	62.5	1:4.5
Alfalfa hay (second cutting)	92.2	11.73	42.38	.72	60.99	1:3.8

[1] Analyses taken from Henry and Morrison's "Feeds and Feeding."
[2] Analyses compiled by the Bureau of Chemistry.
[3] Experiments conducted by the Wyoming Agricultural Experiment Station.
[4] The nutritive ratio is the ratio which exists between the digestible crude protein and the combined digestible carbohydrates and fat.

Table IV shows that the percentage composition of both green and cured sweet clover compares favorably with that of alfalfa and red clover.

Perhaps the most interesting point shown in this table is that the fiber content of white sweet clover, whether green or cured into hay, is no greater than that of alfalfa. It is understood, however, that the plants collected for these analyses were taken when they were at the proper stage for curing into hay. Table IV also shows that the digestible nutrients of sweet clover when fed to sheep compare favorably with alfalfa. It was stated that the sweet-clover hay used for this experiment was stemmy and that it had not been cut until it had become woody. The pea hay had passed the best stage for cutting when it was harvested, while the alfalfa hay was in excellent condition.

In a feeding experiment with sheep conducted by two students at the Iowa State College it was found that the protein digested in sweet-clover feed alone was 69 per cent and that the addition of corn to the hay ration increased the digestibility of sweet clover to 82 per cent. Alfalfa and red clover showed similar increases of the digestibility of the protein content when corn was added to the ration. The percentage of digestibility figured for the protein in the corn was the average of a number of digestion experiments. The probability is that the digestibility of the corn was also increased by the presence of the hay in the ration, so that not all the increase in the digestibility should be credited to the hay constituents of the different rations.

FEEDING EXPERIMENTS WITH SWEET CLOVER.

Few agricultural experiment stations have carried on definite feeding experiments to determine the value of sweet clover as compared with other feeds.

The South Dakota Agricultural Experiment Station reported an experiment in which lambs were fed on sweet-clover hay in comparison with alfalfa, pea-vine, and prairie hay. In this experiment the lambs made a better gain at a less cost when fed sweet-clover hay than when fed pea-vine hay, but not as large a gain as when fed alfalfa hay. The results of this experiment are shown in Table V.

TABLE V.—*Feeding experiment with lambs in South Dakota, showing the comparative value of different kinds of hay as roughage.*

[Grain ration consists of oats and corn in all cases; roughage varies.]

Roughage fed.	Number of lambs.	Duration of test.	Average weight.		Required for 1 pound of gain.		Average daily gain per head.
			At beginning.	At end.	Grain.	Hay.	
		Days.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pound.*
Prairie hay	10	67	83.6	107.9	5.09	2.35	0.36
Pea-vine hay	10	67	83.6	107.3	5.40	3.15	.35
Alfalfa hay	5	67	81.4	119.4	3.36	3.02	.56
Sweet-clover hay	10	67	84.7	113.6	4.42	3.19	.43

The Wyoming Agricultural Experiment Station also performed an interesting experiment with lambs. A number of pens of 10 to 40 lambs each were fed different mixtures of feeds for 14 weeks. Those receiving sweet-clover hay, corn, and a small amount of oil meal made an average gain of 30.7 pounds per head, as compared with 20.3 pounds for those receiving native-grass hay, oats, and oil meal. Those receiving alfalfa hay and corn made a gain of more than 34 pounds per head. The results obtained with four pens of lambs in this experiment are given in Table VI.

TABLE VI.—*Results of feeding tests of lambs in Wyoming covering 14 weeks.*

Ration.	Number of lambs.	Average gain per head.	Required for 100 pounds of gain.					
			Sweet-clover hay.	Native hay.	Alfalfa hay.	Corn.	Oats.	Oil meal.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Sweet-clover hay, corn, and oil meal (old process)	10	30.7	637.5			293.2		20.5
Native-grass hay, oats, and oil meal (old process)	40	20.3		606.7			460.5	25.0
Alfalfa hay and corn	10	34.4			557.7	264.6		
Do	40	34.3			557.3	286.5		

The sweet-clover hay used in this experiment was described as stemmy and more than a year old; yet it was eaten up clean by the lambs.

The South Dakota Agricultural Experiment Station conducted an experiment in which steers were fed corn silage and various kinds of hay, including sweet clover. The steers which were fed corn silage and sweet-clover hay made an average daily gain of 2.45 pounds, at a cost of $4.34 per hundred pounds of gain, whereas the steers which were fed corn silage and red-clover hay made an average daily gain of 2.29 pounds, at a cost of $4.55 per hundred. The steers that were fed corn silage and alfalfa hay made an average daily gain of 2.49 pounds, at a cost of $4.30 per hundred. In computing the cost of the gains, corn silage was valued at $3 per ton, alfalfa, red-clover, and sweet-clover hay at $10 per ton, and prairie hay at $6 per ton. The results of this experiment, as given in Table VII, show that sweet-clover hay is practically equal to red-clover and alfalfa and greatly superior to prairie hay for roughage for steers.

TABLE VII.—*Feeding experiments with steers in South Dakota, showing the value of sweet-clover hay as compared with some other kinds of hay.*

[Corn silage fed in all cases; kind of hay varies.]

Roughage.	Number of steers.	Duration of test.	Average weight.		Average daily gain.	Feed per pound of gain.		Cost per 100 pounds of gain.
			At beginning.	At end.		Silage.	Hay.	
		Days.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	
Red-clover hay	4	91	775	983	2.29	25	1.5	$4.55
Sweet-clover hay	4	91	774	997	2.45	23	1.5	4.34
Alfalfa	4	91	778	1,005	2.49	23	1.6	4.30
Prairie hay	4	91	769	951	2.01	[illegible]	1.5	4.79

The results of these various experiments are being duplicated every year by many feeders. Each year in the Middle West and Northwest many cattle that bring high prices are being fed with no other roughage than sweet-clover hay. Steers which have been pastured entirely on sweet clover have brought in the Chicago market $1 per hundredweight more than ordinary grass-pastured stock marketed from the same locality and at the same time.

Excellent results were obtained in Lee County, Ill., from feeding steers sweet-clover silage made from plants which had matured a seed crop. For this experiment 91 head of steers 2 and 3 years old, averaging 1,008 pounds per head, were purchased at the Kansas City stockyards on November 16, 1915, at a cost of $6.30 per hundred. These steers were shipped to a farm at Steward and immediately turned on 120 acres of cornstalks. They were fed nothing in addition to the cornstalks until January 14, 1916, when they were put into the feed lot. While they were not weighed when turned into the feed lot, the owner of the steers stated that in his estimation they had gained but little, if any. During the 60 days these steers were in the feed lot they were fed 25 bushels of snapped corn twice a day and as much sweet-clover silage as they would eat. These animals had access to sweet-clover straw during the first part of the feeding period, but after this was consumed they had only oat straw as roughage. At the end of the feeding period they were sold on the Chicago market at the average price of $8.25 per hundred, netting approximately $35 per head. The average weight of these steers in the Chicago yards was 1,177 pounds, 169 pounds more than when purchased in Kansas City.

A most remarkable feature of this experiment is the fact that the steers were fed almost entirely material which would have been considered of little value by the average farmer. The corn which was fed tested 44 per cent moisture at the Rochelle, Ill., elevator, and 20 cents per bushel was the best price offered for it.

Presumably on account of wet weather during the fall of 1915, the sweet-clover seed crop was a failure in that section; in fact, the crop had been cut for seed and part had been thrashed before it was decided that the seed yield was not sufficient to pay for the thrashing. The remainder of the crop was then run into the silo and fed to the steers. The leaves fall and the stems of this plant become hard and woody as the seed matures. The crop therefore would have been worthless for feed had it not been placed in the silo. As a rule, stock readily eat sweet-clover straw when the stems are broken and crushed by the hulling machines. The sweet-clover straw which was used as roughage during the first part of the feeding period was from that part of the seed crop which had been thrashed.

An interesting feeding experiment was conducted on a farm at Rochelle, Ill. On September 7, 1913, 29 head of 2-year-old steers, averaging 836 pounds, were turned on 40 acres of sweet clover which had been seeded that spring with barley. These animals were pastured on the sweet clover until November 1 without additional feed. During this time they made exceptionally large gains. From November 1 to December 11, 28 head of these steers had access to an 80-acre field of cornstalks. On December 11 they were put into the feed lot. During the time these steers were on the cornstalks they barely held their gain, but during the first 30 days they were in the feed lot they made an average daily gain of almost 3 pounds. In this period they received 215 bushels of corn-and-cob meal and 16¾ tons of silage made from the first-year growth of sweet clover. During the next 30 days they received 388 bushels of corn-and-cob meal and much less sweet-clover silage. During this time they made an average daily gain of 2 pounds. When the corn-and-cob meal ration was increased the steers ate less silage. These cattle dressed 55⅛ per cent at a Chicago packing house.

SWEET CLOVER AS A SOIL-IMPROVING CROP.

Unlike many legumes, sweet clover will make a good growth on soils too depleted in humus for profitable crop production. In addition to its ability to grow and to produce a considerable quantity of forage on such soils, it will add much humus to them. The extensive root systems do much toward breaking up the subsoil, thereby providing better aeration and drainage. The effect of the large, deep roots in opening up the subsoil and providing better drainage is often very noticeable in the spring, as the land upon which sweet clover has grown for several years will be in a condition to plow earlier than the adjacent fields where it has not been grown. The roots are often one-eighth of an inch in diameter at a depth of 3 feet, and they decay in five to eight weeks after the plants die. (Figs. 12 and 13.) The holes made by the roots are left partly filled with a fibrous substance which permits rapid drainage. Sandy soils are benefited materially by the addition of humus and nitrogen, while hardpan often is broken up so completely that alfalfa or other crops will readily grow on the land. The roots add much organic matter to the layers of soil below the usual depth of plowing, while those in the surface soil, together with the stubble and stems, when the crop is plowed under, add more humus than possibly any other legume which may be grown in short rotations. Not only does this crop add organic matter to the soil, but in common with other legumes it has the power of fixing atmospheric nitrogen by means of the nitrogen-gathering bacteria in the nodules on the roots.

The ability of sweet clover to reclaim abandoned, run-down land has been demonstrated in northern Kentucky and in Alabama. In

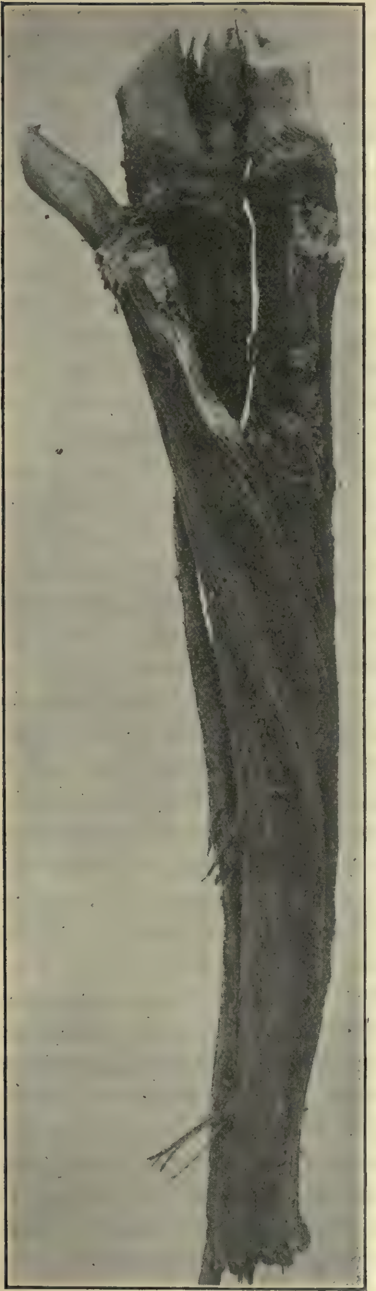

FIG. 12.—A portion of a root of sweet clover, collected 30 days after the seed crop had been cut. The cortex was so decayed that it remained in the ground when the root was removed. Note that the pith has largely disappeared and that the half-rotten central cylinder is all that remains.

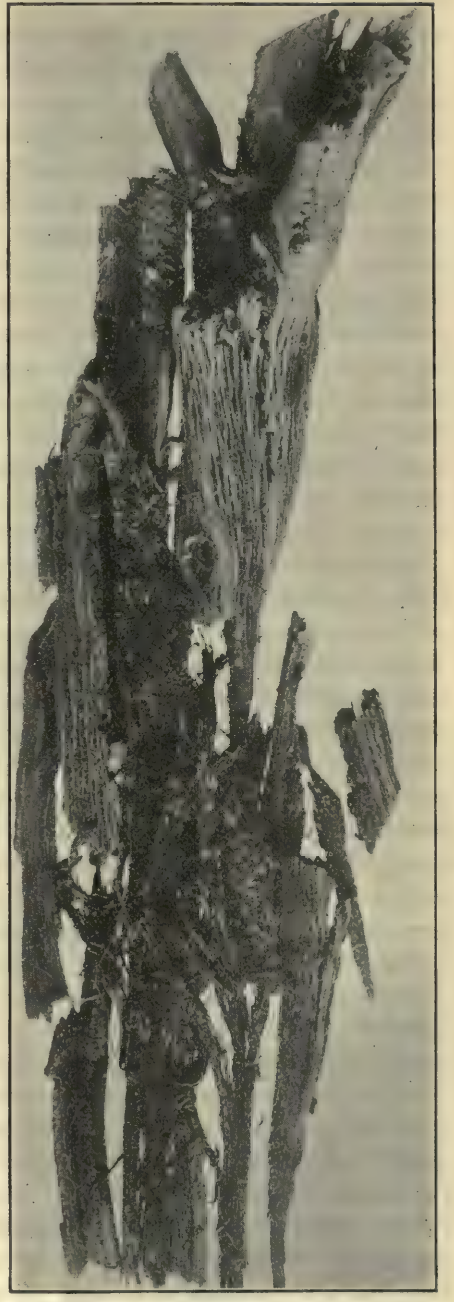

FIG. 13.—The same root shown in figure 12 after being crushed between the thumb and forefinger, illustrating how rapidly sweet-clover roots decay after the plants die. The holes left in the ground by the rapid decay of the roots facilitate drainage.

these regions many farms were so depleted in nitrogen and humus by continuous cropping with nonleguminous crops that profitable yields could be obtained no longer. Through the use of this crop many of these farms have been brought back to a fair state of fertility. Tests at the Alabama Agricultural Experiment Station show that the increased yield of corn following sweet clover which had occupied the land for two years was 6¾ bushels per acre. The cotton grown on the land the second year showed an increase of 56 pounds per acre. The combined value of the increased yields of corn and cotton for the two years was estimated at $9.75. The total yield of hay for the two preceding years was 6.8 tons per acre. In another experiment at this station cotton was planted on land that had grown sweet clover the two previous years and on land that had received an application of 18 tons of stable manure per acre. The sweet-clover plat produced 280 pounds of seed cotton the first year and 120 pounds of seed cotton the second year more than the plat which received the heavy application of manure.

Land on which sweet clover had been grown for four years at the Ohio Agricultural Experiment Station yielded 26.9 bushels of wheat per acre as compared with 18.6 bushels on the check plat. Sweet clover was seeded at the Tennessee Agricultural Experiment Station in the spring of 1912. One cutting of hay was removed that year and the following spring the field was plowed and planted to corn. The corn yielded 58.8 bushels per acre as compared with 41.1 bushels per acre for an adjoining plat where rye was turned under. A number of tests have been conducted in southeastern Kansas which show clearly the value of sweet clover as a soil-improving crop for that section. The yield of wheat has been increased as much as 7 bushels per acre and that of corn as much as 22 bushels per acre by plowing under the second-year growth of clover.

Annual yellow sweet clover is rapidly gaining in favor as a green-manure crop for orchards in the Southwest. In Arizona two plats seeded in October and plowed under in April yielded, respectively, 16 and 17 tons of green matter to the acre. At the Arizona Agricultural Experiment Station annual yellow sweet clover, lupines, and alfalfa were tested as green-manure crops for orchards. In this experiment the sweet clover clearly showed its superiority to lupines or alfalfa for this purpose, as it yielded from 21 to 26 tons of green matter per acre, whereas the highest yield for the lupines was 10 tons and for the alfalfa 15 tons per acre.

The use of annual sweet clover as a green-manure crop in southern California has increased very rapidly in recent years, and this increased use apparently has been justified by the results obtained with it. One of the most interesting green-manure tests thus far noted was conducted at the California Citrus Experiment Station. In this experiment nine legume plats and eight nonlegume plats alternated with each other. The 4-year average weight of green matter produced on the sweet-clover plat was 14¾ tons per acre, whereas the 5-year average weight of green matter produced by common vetch and Canada field peas was 12 tons and 9 tons, respectively, per acre. On one series of these plats corn was planted in rotation with the clover. The average yield of shelled corn for four years was 46 bushels to the acre on the sweet-clover plat, as compared with 35 bushels to the acre on the common-vetch plat and 40 bushels per acre on the field-pea plat. One barley plat receiving each year an application of 1,080 pounds of nitrate of soda gave an average yield of 41 bushels per acre. The 2-year average yield of potatoes following sweet clover was 252 bushels per acre, as compared with 171 bushels following common vetch and 234 bushels following field peas. Sweet clover has proved to be an excellent plant to grow in rotation with sugar beets, as the 2-year average for the beets following it was 19.8 tons per acre, as compared with 15.3 tons following common vetch, and 17.6 tons following field peas.

Annual yellow sweet clover makes a profitable growth only in the South and Southwest and therefore should not be planted in any other section of the country.

In those sections of the United States where the soils are low in humus it is to be strongly recommended that sweet clover be grown for green manure. This method is being practiced in some sections of the country with excellent results.

It should be remembered that sweet clover will not make a satisfactory growth on acid soils and that it is very essential to provide inoculation if the soil is not inoculated already.

SWEET CLOVER IN ROTATIONS.

As sweet clover is a biennial plant, it lends itself readily to short rotations. It may be seeded in the spring on winter grain or with spring grain, the same as red clover. It will produce at least as much pasturage the following fall as red clover, and in some parts of the country a cutting of hay may be obtained after the grain harvest. The following year the plants will produce two cuttings of hay or one cutting of hay and a seed crop. In some sections of the United States this plant is replacing red clover in rotations, as it will succeed on poorer soils than red clover and will add much more humus to the soil. It will withstand drought better than either red clover or alfalfa, and on this account its use in rotations may be extended into drier sections. As a rule the beneficial effect of sweet clover on the subsequent crops is more marked than that of other legumes. This is especially true with corn, and whenever possible corn should follow sweet clover in rotations. Root crops also are benefited by its use in rotations, as the large deep roots of sweet clover open up the soil.

SWEET CLOVER AS A HONEY PLANT.

A number of the leading honey plants fail to secrete nectar in part of the territory in which they are found, but white sweet clover ranks as a valuable source of nectar wherever found in sufficient quantity in the United States. The period of nectar secretion usually follows that of white and alsike clovers in the Northern States, and consequently comes at a time when the colonies are strong enough to get the full benefit of the secretion. The honey from white sweet clover is light in color, with a slight green tint, the flavor being mild and suggestive of vanilla. The characteristic flavor and color of the honey seem to be less marked during a rapid secretion of nectar. In the irrigated portions of the West honey from white sweet clover is often mixed with that from alfalfa.

Beekeepers have long recognized the value of sweet clover as a source of nectar, and for years tons of seed have been sold annually by dealers in beekeepers' supplies. It has never been found profitable to cultivate any plant solely for nectar, and those beekeepers who were primarily interested in the plant for bee forage have scattered the seed chiefly in waste places and along railroad embankments and roadsides. A number of beekeepers who were also engaged in general farming have for years utilized the plant for forage, and they were among the earliest to grow the plant for seed, so as to be able to supply their fellow beekeepers. Sweet clover to-day is almost the only plant which beekeepers seek to increase in waste lands in their localities.

The yield of nectar from sweet clover is heavy, and a number of beekeepers now market this honey in carload lots. Sweet clover is utilized for honey especially in Kentucky, in Iowa, and in Colorado and adjacent States. In Alabama and Mississippi a number of beekeepers are harvesting large crops chiefly from this source. The color and flavor make this plant suitable for either comb or extracted honey.

Yellow sweet clover is perhaps as valuable for nectar as white sweet clover, but beekeepers have paid less attention to it. This is probably due to the fact that the blooming period of the yellow species often coincides with that of white and alsike clover, making it less valuable to the beekeeper. In sections where the quantity of white and alsike clover is limited and it is desired to plant sweet clover for bee pasturage, a mixture of the white and yellow species is recommended, as the yellow species will bloom from 10 to 14 days earlier than the white.

Wherever any of the species of sweet clover are cultivated, either for forage or for seed, beekeeping is to be recommended as a valuable source of additional income, and such locations are especially suitable for extensive commercial beekeeping.

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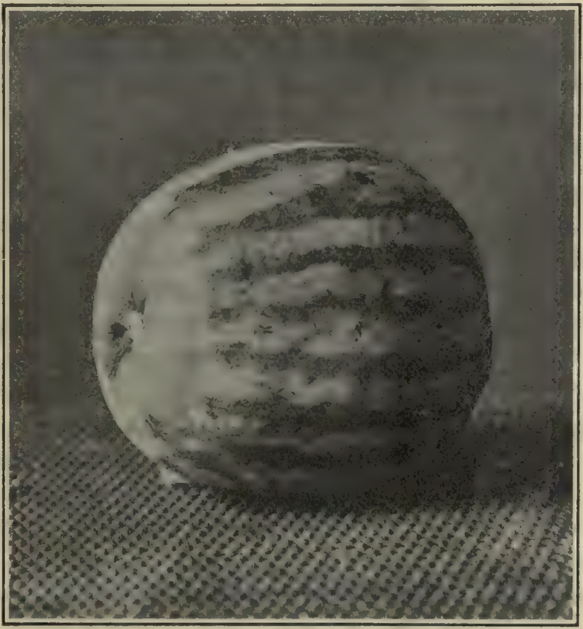
WATERMELON DISEASES

W. A. ORTON

Pathologist in Charge of Cotton, Truck, and Forage Crop
Disease Investigations



FARMERS' BULLETIN 821

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. May, 1917

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IN most of the commercial watermelon-growing districts of the South it is best to select land never previously used for this crop and never exposed to contamination by drainage water, by material from old melon fields introduced in stable manure, or by other means.

Land infested with root-knot should be avoided. Root-knot in the soil can be detected by examining the roots of the preceding crop and of the weeds in the field for galls or enlargements. If these are found, a special rotation of winter grain, velvet beans, corn, and other crops immune to root-knot is advisable.

The blighting of the foliage and the spotting of the melons from anthracnose may be prevented by thorough spraying with Bordeaux mixture during the month preceding the maturity of the crop.

To avoid stem-end rot the most important measure is the disinfection of the cut stems with a bluestone paste when the melons are being loaded into cars. It is helpful also to cut and burn the weeds along fences and ditch banks and to remove and destroy all cull melons.

WATERMELON DISEASES.

CONTENTS.

	Page.
Need of cooperation for control of watermelon diseases	3
Descriptive key to watermelon diseases	3
Watermelon wilt	4
Root-knot	6
Anthracnose	6
Stem-end rot	11
Minor diseases	17
Summary of control measures	18

NEED OF COOPERATION FOR CONTROL OF WATERMELON DISEASES.

THIS bulletin deals primarily with diseases of watermelons as found in the Southeastern States, whence some thousands of carloads are shipped each year to northern markets. The information is, however, applicable to other sections of the country wherever any of the diseases mentioned occur.

The Department of Agriculture is prepared to assist growers in carrying the recommended control measures into effect through its advisory relations with county agents and State extension workers. There is, however, need for a readjustment of marketing conditions and the cooperation of buyers and shippers in securing for the grower a return for his field work in controlling anthracnose and stem-end rot. At present the ownership and responsibility for the melons are shifted when the car is loaded, and growers of infected melons receive the same price as those who spray and treat their fruit. Shippers as well as farmers should understand the relation which field conditions bear to the keeping qualities of watermelons, as described more fully in later pages of this bulletin.

For convenience in reference and identification of the several diseases, the descriptive key given below has been prepared.

DESCRIPTIVE KEY TO WATERMELON DISEASES.

Symptoms.	Disease.
A. The vines wilt suddenly, beginning at the ends of the branches	Wilt.
B. The vines lack vigor and the melons remain small; roots greatly enlarged	Root-knot.
C. The leaves show dark spots and tend to shrivel up. (See also "Malnutrition," p. 17)	Anthracnose.
D. The fruit is spotted with small pits	Anthracnose.
E. The fruit decays at the stem end	Stem-end rot.
F. The fruit decays at the blossom end	Blossom-end rot.
G. The fruit decays where it rests on the ground, with abundant white mold	Ground rot.

WATERMELON WILT.

In most watermelon sections the experience of many years has established the fact that two successive crops of watermelons can not be grown on the same land without risk of failure and that 10 years or more must pass before old melon fields may be replanted. It is more than 20 years since Dr. Erwin F. Smith showed that the cause of these failures is a specific disease, the wilt, and outlined the procedure by which losses may be avoided.

CHARACTERISTICS OF WILT.

The name of the disease indicates its most prominent symptom. Affected vines wilt suddenly and do not recover. Usually one branch after another wilts, beginning at the tip, and dries up until the whole vine is dead. This may occur at almost any time during the growing season, but is most noticeable when the fruit is setting.

Cut the stem, and the woody portion will be found discolored (fig. 1). If a microscope were available, the browned areas, which are the water-carrying vessels, would be seen to be plugged with slender, colorless mold filaments, the watermelon wilt fungus.

CAUSE OF WILT.

The cause of wilt is a fungus[1] which attacks only watermelons. It lives in the soil, enters the small roots, and grows up through the water vessels, which it plugs to such an extent as to cause the vine to wilt. After the death of the vine the fungus grows out to the surface of the ground and there forms multitudes of spores—minute seed bodies—which spread it very widely.

Few soil diseases spread as rapidly as the watermelon wilt or remain longer in infected soil. It is carried by drainage water, on the feet of live stock, in stable manure, and in other ways.

It has a preference for light, sandy soils, and different types of soil vary in their liability to infection and in the period of rotation necessary to free the land of the disease. This is a point to be determined by local experience. Watermelon wilt now occurs from the Atlantic to the Pacific and from the Gulf of Mexico to Iowa and Maryland. It is in sections where it is newly introduced that the directions given in this bulletin will be most helpful if followed, as the older sections have learned them by experience.

CONTROL OF WILT.

The following control measures have all been shown to be of practical importance:

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[1] *Fusarium niveum* Erw. Sm.

(1) *Rotation of crops.*—Watermelons must not be planted twice in the same place if wilt prevails. The period which must elapse before the land can be considered free from infection is set by different growers at 10 or 12 years, or longer. This, of course, does not apply to those sections where wilt does not occur and where short-term rotations may be followed.

(2) *Control of drainage water.*—Land which has received drainage or flood water from a melon field may be considered infected. In selecting land for melons, plant the lower fields first and the hilltops last.

(3) *Avoidance of stable manure.*—The wilt fungus grows well in stable manure, and a field to which infected manure or compost is applied is almost invariably a failure. Most stables become infected from portions of melon vines brought in with hay cut from melon fields after the crop is off and remain so infected from year to year, indefinitely. Consequently in districts where wilt prevails it is advisable to use only commercial fertilizer for watermelons.

(4) *Control of live stock.*—The wilt is spread also by cattle and horses which range from an old melon field to other fields which may be planted to melons later. Scattered cases of wilt traceable to this cause have been observed to be most frequent along the paths to water and near trees where the animals congregate.

(5) *Resistant varieties.*—None of the standard varieties of melons is materially resistant to wilt. A wilt-resistant variety, named Conqueror, has been bred by the Department of Agriculture by crossing the Eden with the stock melon or citron (fig. 2), and a similar line of breeding, continued by the North Carolina Agricultural Experiment Station, has also resulted in the production of a resistant melon. Neither of these varieties is recommended for general use at present. The Conqueror is an oval, striped melon, a type not popular in the markets, and while of good quality when grown in the sand hills of South Carolina, where it was originated, it has shown a tendency to vary from type in some cases when grown elsewhere.

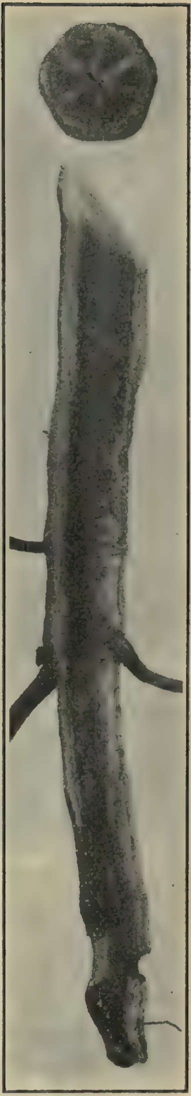

Fig. 1.—Watermelon wilt. Cross and longitudinal sections of the stem of a diseased plant, showing the blackening of the wood characteristic of the disease.

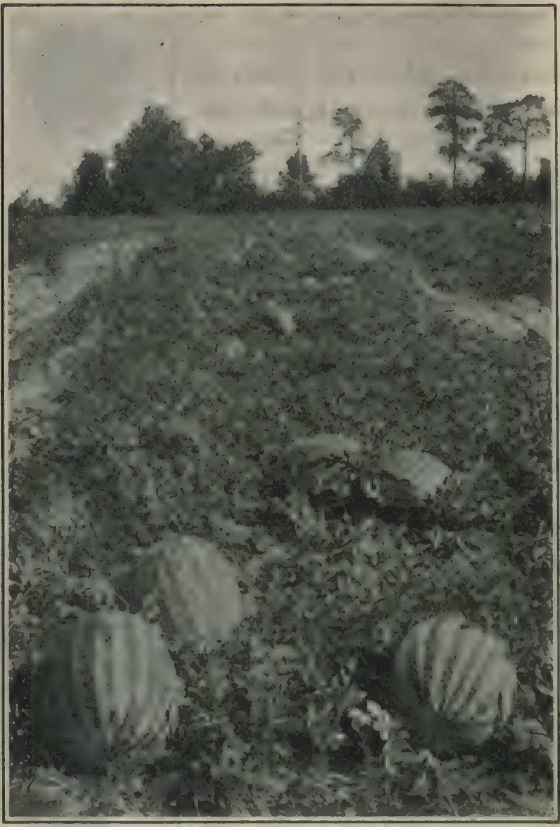

FIG. 2.—Resistant watermelons. A field of Conqueror melons free from wilt on a badly infected field where all other varieties failed.

Thus far, also, enough new land has been available to furnish an ample acreage for melons. Ultimately it would seem that a resistant variety will be needed, and it is felt that the way has been found to produce one.

ROOT-KNOT.

The watermelon is very susceptible to injury by the root-knot nematode,[1] a pest very widely distributed in the South on most vegetables, cotton, cowpeas, etc., and some losses to melon growers have occurred.

The aboveground effect of root-knot is mainly a stunting or reduction in vigor of vine and size of fruit. The roots are the seat of the injury and these are greatly swollen, distorted, and knotted. (Fig. 3.)

Root-knot is a pest of old fields, and the practice of growing melons on new land fortunately avoids much loss. Growers, however, should bear in mind the susceptibility of this crop to root-knot whenever considering the planting of old fields.

Root-knot can be controlled in a practical way only by a system of rotation with nonsusceptible crops, such as winter grains, corn, velvet beans, and Iron or other resistant cowpeas. For a full discussion of this important matter, consult Farmers' Bulletin 648, "The Control of Root-Knot," which will be sent free upon application to the Department of Agriculture.

ANTHRACNOSE.

One of the most troublesome watermelon diseases is anthracnose. This affects the leaves and vines as well as the fruit. Irregular, dark, dead spots appear on the leaves, which dry up and die prematurely. The stems may be spotted in a similar way.

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[1] *Heterodera radicicola* (Greef) Müller.

The melons may develop spots, at first water-soaked and later sunken and covered with a pink growth of spores. (Fig. 4.) Hundreds of these spots of varying sizes may appear on a single fruit. At first shallow, they may become deeper and result in the decay of the flesh when followed by other fungi. In any case the melons are disfigured and their market value much lessened.

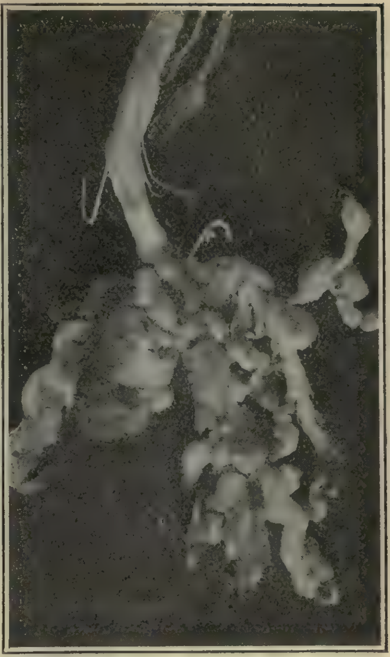

FIG. 3.—Root-knot. Melon root, showing galls caused by nematodes.

CAUSE OF ANTHRACNOSE.

Anthracnose is due to a fungus[1] widely prevalent not only on watermelons but also on cucumbers, cantaloupes, and other plants of the cucurbit family. Closely related but different fungi cause the anthracnose of cotton, bean, and sugar cane, citrus wither-tip, and similar diseases of many other crops.

The fungus, which is itself a plant, penetrates the watermelon and develops there in the form of minute moldlike threads. It is spread widely and rapidly by its tiny seed bodies, or spores, produced in uncountable numbers on the spotted leaves and fruit. Without moisture these spores can not germinate or infect the plant; hence, anthracnose may not appear at all during dry weather, but it develops very rapidly during periods of rain or heavy dews, particularly if the weather is warm. The anthracnose fungus has a peculiar ability to remain dormant in the melon rind and develop into visible spots later when heat and moisture conditions are favorable; consequently, the disease often appears almost overnight on whole carloads en route to market if the weather is warm and muggy. The original infection, however, is to be traced back to the field, where the foliage was blighted.

The premature death of the leaves has other unfavorable consequences in that the melons can not ripen normally and their flavor is inferior. The fruit is also no longer shaded from the sun and tends to sunburn.

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[1] *Colletotrichum lagenarium* (Pass.) Ell. and Halst.

CONTROL OF ANTHRACNOSE BY SPRAYING.

Anthracnose can be prevented by spraying with Bordeaux mixture if it is done thoroughly and at the proper times. In seasons when the disease is severe two or three applications will save the crop, of which half or more might otherwise be lost. The accompanying illustrations (figs. 5 and 6) show the results of such spraying with only two applications.

Inasmuch as some trials of spraying have failed to give satisfactory results, the attention of growers is directed to some essential details the neglect of which was responsible for all failures investigated.

Dates and number of applications.—The weather is the deciding factor. It has been pointed out that the disease can not spread without moisture and that its severity is proportional to the number of rainy days during the period when the melons are ripening. Since it is desirable to avoid the expense of unnecessary sprayings, the weather and the fields should be watched closely. If a drought prevails during the early growing season, spraying may be postponed until two weeks before ripening time, when a thorough spraying should be given. If evidences of the disease on the leaves are detected earlier, spraying should begin sooner. Second and third

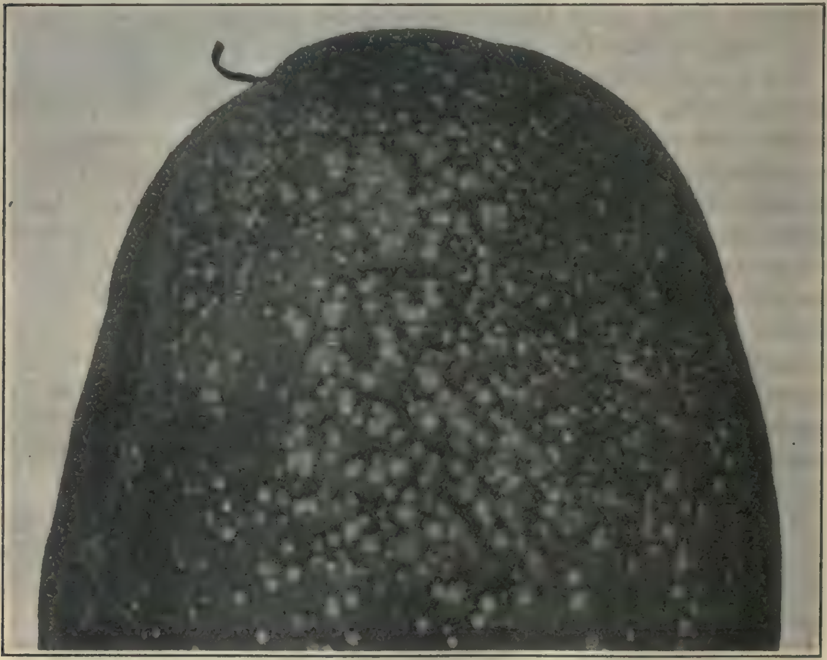

FIG. 4.—Anthracnose. Portion of a watermelon showing the small, depressed spots characteristic of this disease.

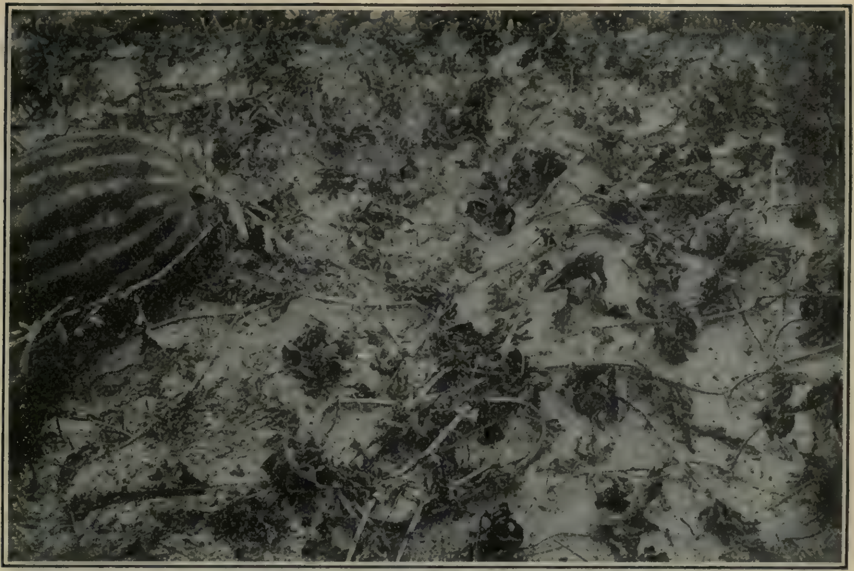

FIG. 5.—Part of an unsprayed watermelon field, showing the foliage killed by anthracnose.

applications should be given at intervals of 5 to 10 days, depending upon the rainfall. The more rain, the more one must spray. It is better to spray in advance of a rain rather than after it, provided there will be time for the Bordeaux mixture to dry on the leaves. Once dry it is not easily washed off.

Methods and apparatus.—For large melon fields under southern conditions a power sprayer similar to those used for orchards is most effective. No material change in equipment will be needed, unless it may be to provide longer lines of hose, so as to reach 25 to 30 feet on each side of the sprayer. Keep open throughout the season, at intervals of 50 to 70 feet, such roadways as will be needed later for hauling out the melons.

Spray under high pressure—140 to 200 pounds. Spray thoroughly, covering as much of the under sides of the leaves as is practicable. Provide loading stations with elevated platforms for refilling the sprayer with Bordeaux mixture and use stock solutions when possible, as this saves time and reduces expense.

How to make homemade Bordeaux mixture.—The several ingredients should be used in the following proportions:

Copper sulphate	4 pounds.
Quicklime	4 pounds.
Water to make	50 gallons.

Prepare the copper sulphate by suspending it in a gunny sack just below the surface of several gallons of water in a clean barrel. When the sulphate is dissolved, which requires three or four hours, remove

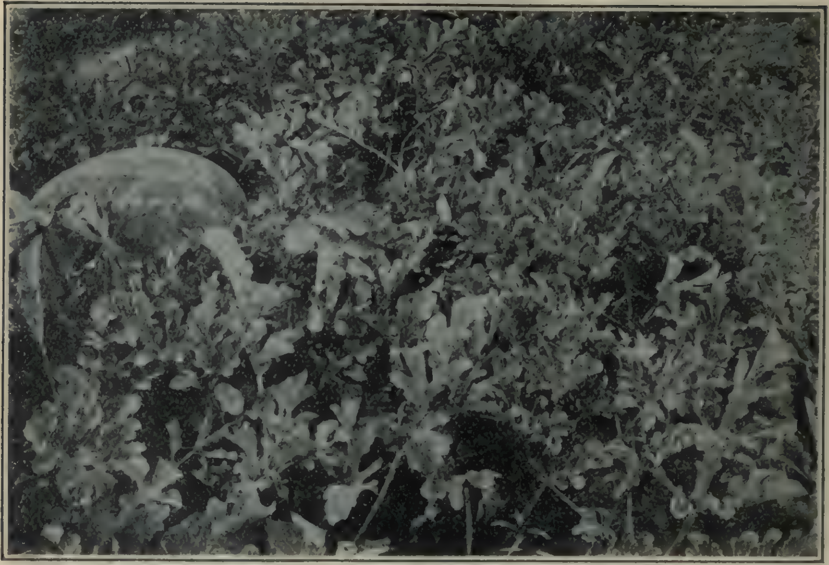

FIG. 6.—Anthracnose control by spraying. A hill adjacent to the field a part of which is shown in figure 5, but which had been protected by two sprayings with Bordeaux mixture.

the sack and stir into the barrel enough additional water to make exactly 25 gallons of the copper solution.

Prepare the lime by slaking it slowly and thoroughly in a clean barrel, strain, and add enough water to make exactly 25 gallons of lime milk. Stir thoroughly.

Pour the two ingredients together into another barrel, or, better, directly into the spray tank if it will hold 50 gallons. It is highly important to stir the mixture very thoroughly and to strain both ingredients before they are combined, as otherwise the clogging of the spray nozzles may result. Use a copper or bronze wire strainer of 18 meshes to the inch. Do not put copper sulphate or Bordeaux mixture into tin or iron vessels; use wood or copper containers. Prepare the Bordeaux mixture as needed and apply at once. It is never so good after it has settled.

Stock solutions.—Everyone who uses Bordeaux mixture frequently and in quantity will find it convenient to keep concentrated stock solutions on hand, as these keep indefinitely if the water which evaporates is replaced.

Build an elevated platform to hold the barrels. Suspend 50 pounds of copper sulphate to dissolve in a 50-gallon barrel of water. Slake 50 pounds of lime in another barrel. Add water to make 50 gallons of lime milk. When Bordeaux mixture is needed, stir both stock barrels and take from each as many gallons as the formula calls for in pounds. Dilute the copper sulphate in one barrel and the lime milk in another, each with half the water, and let the two run together into the strainer of the spray tank.

To those who expect to spray on a large scale, more detailed instructions about fungicides and their application than can be given here are available in Farmers' Bulletin 243 of the United States Department of Agriculture, "Fungicides and Their Use in Preventing Diseases of Fruits."

Cost of spraying.—The cost of spraying depends upon factors which vary according to locality and season, including the number of applications needed, the wages and efficiency of the labor, and the cost of materials. The copper sulphate should be bought in wholesale quantities. One hundred gallons of Bordeaux mixture per acre are required for thorough spraying, and 12 to 20 acres per day can be covered with one power outfit.

STEM-END ROT.[1]

A rapid decay, usually beginning at the stem end and developing during transit to market, has caused losses during recent years that for some sections have been perhaps more serious than any other melon disease. Many cars have reached their destination with 75 to 95 per cent of their contents spoiled. On one day in 1915 in 100 cars on the tracks in a large northern market an average of 25 per cent of the melons was decayed with stem-end rot. So accustomed have the melon handlers become to this disease that it is a common practice when unloading to test every melon as it is passed out of the car by exerting pressure with the thumb at the stem end. If the rind gives way, the melon is rejected.

The first indication of the trouble is a browning and shriveling of the stem. Decay of the melon begins at the point of attachment to the stem, where the flesh softens and takes on a water-soaked appearance. An illustration of such a diseased watermelon is shown on the title-page. A band of decay progresses down the fruit at the rate of half an inch to 1½ inches a day and under moist conditions soon becomes covered with a dark-gray mold. (Fig. 7.) The flesh of the melon becomes soft and slimy.

The same type of decay may begin at a point on the side of the melon where there is a wound or bruise, and it is very common in the fields as a blossom-end rot. These melons, if left in the field, become wrinkled, black mummies, and are dangerous centers of infection. (Fig. 8.)

CAUSE OF STEM-END ROT.

Stem-end rot is due to a fungus[2] closely related to or identical with species which cause a stem-end rot of citrus fruits, a decay of sweet potatoes, a cotton boll-rot, and other plant diseases. They are all alike in being wound or weakling parasites, that is, they will not attack a living plant or fruit unless it is weakened or dying from some other cause or has been cut or bruised.

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[1] This section is based on the work of Mr. F. C. Meier, student assistant.

[2] *Diplodia* sp.

The stem-end rot fungus is common on ripe or dying vegetation in and around the melon fields, especially on cotton and corn stalks, coffee weed, and old melon vines. These plants become covered with the black fruiting bodies of the fungus (fig. 9), in which countless spores are borne and from which they are scattered by the wind. In this manner the fungus lives over winter and is carried in the spring to infect the blossom ends of imperfect melons or the cut stems of culls. Such melons, decaying in the field, are the chief sources of

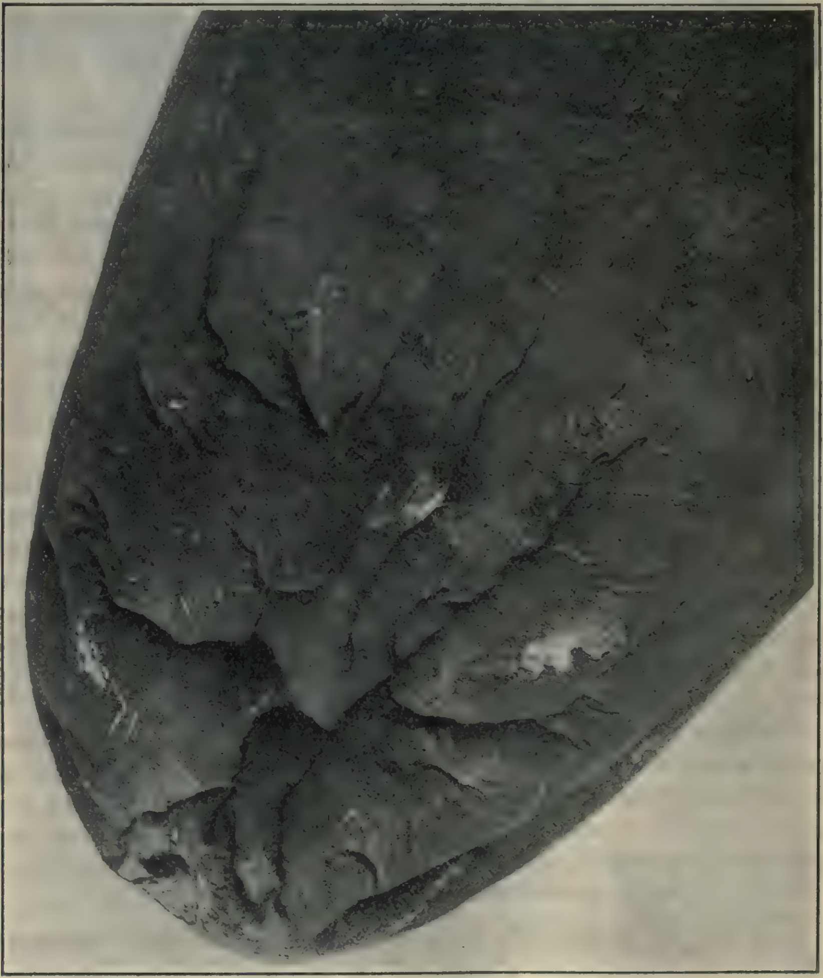

FIG. 7.—Part of a watermelon with stem-end rot.

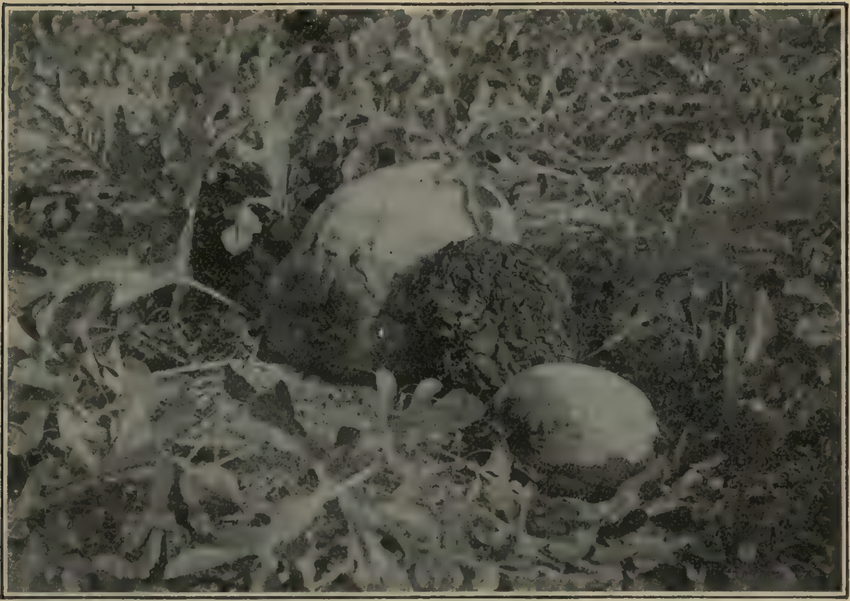

FIG. 8.—Watermelon stem-end rot. Decaying and mummifying culls in the field. These are a source of infection to the remainder of the crop.

infection, as they become literally masses of spores. Figure 10 shows these spores magnified 360 times and illustrates their germination and the beginning of the mold thread which infects the melon.

INFECTION AND DEVELOPMENT.

When a melon is cut from the vine, a drop of sap exudes from the cut stem and provides ideal conditions for the germination and development of the fungus. Since the spores are wind borne, they are abundant in the air and are likely to find lodgment on the cut stems. The knives and hands also are carriers of infection, as the workmen are likely to handle or cut into decaying melons. Within 24 hours the blackening of the cut surface may be perceived, and by about the third day the fungus has grown down the stem into the melon and started a rot.

That sound and healthy melons from well-cultivated fields may be thus ruined within three to five days is difficult for many to believe until they have seen it, but numerous experiments have proved beyond a doubt the nature of the disease and have disproved several ideas that have been advanced concerning it.

RELATION TO FERTILIZERS.

Stem-end rot is not due, as many think, to the use of large quantities of fertilizers or to the excessive use of nitrates or any particular ingredient. Growers may safely continue to fertilize their watermelon fields in the manner that experience has shown to produce the earliest and the largest crops.

RELATION TO VARIETIES.

All varieties of watermelons tested have proved to be subject to stem-end rot. There is no reliable evidence to indicate that the varieties now in cultivation have deteriorated or that those formerly grown were less liable to this disease. The breeding of resistant varieties is not one of the measures indicated for its control.

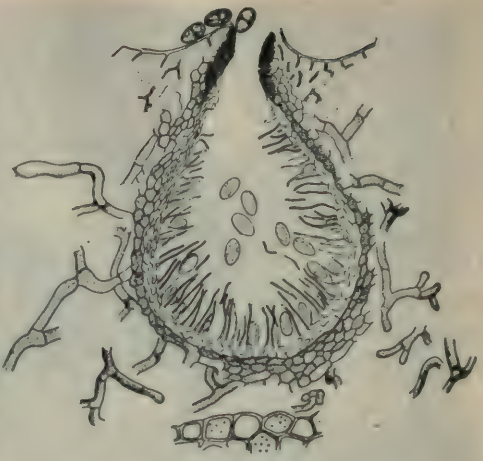

FIG. 9.—Watermelon stem-end rot fungus. Section through a spore case (pycnidium), showing the production of spores. (Greatly magnified.)

RELATION TO MATURITY.

Watermelon fruits are subject to stem-end rot at all stages of development. Green fruits, if infected, will decay as quickly as ripe fruit. The shipping of immature melons, therefore, will not avoid stem-end rot.

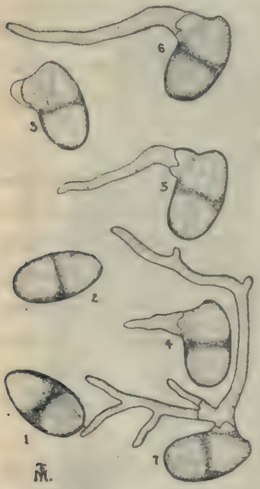

FIG. 10.—Spores of the fungus causing watermelon stem-end rot. Spores taken from a freight car which had contained decayed melons are shown at 1, 2, and 3. Six months later 5 per cent of them were alive and germinated when moistened, as shown at 4, 5, 6, and 7. ×360.

RELATION TO CHEMICAL INJURY.

Before the nature of stem-end rot was understood, the losses were charged to the presence of lime, salt, and fertilizer residues on the walls of cars. Extended experiments have now shown that injuries from such substances are not common and that the effect produced by chemicals can be distinguished readily. It is confined, in the first place, to melons that have been in contact with car walls or floors, and, in the second place, to the sides of the melons which are abraded; or, in cases where the fertilizer residues were wet, there may be shallow, brown depressions in the rind, which do not decay until fungi have gained entrance.

Chemical injury (fig. 11) has been found to cause a very small fraction of the losses among watermelons at terminal markets. It can be avoided by cleaning the cars thoroughly before loading them with melons and by the use of a strong paper for lining.

CONTROL MEASURES.

The prevention of stem-end rot is to be accomplished by keeping the spores of the causal fungus from entering the cut stem. Two lines of action are advisable: (1) Field sanitation, to reduce the danger of infection, and (2) stem-end treatment with a disinfectant.

Clean up the fields.—It has been shown that dead vegetation of nearly all kinds is likely to harbor the stem-end rot fungus. The first step, therefore, is to clear and burn the weeds and rubbish in the fence rows and along ditch banks. This should be done in the winter. Deep plowing, to turn all the vegetation in the field so far under the ground that it will not be exposed by next season's cultivation, also should be helpful. Both these measures are in any case demanded by good farm practice, particularly in the boll-weevil districts.

Gather and destroy all cull melons.—During the growing period the fields should be gone over once a week and all imperfect or cull melons, blossom-end rots, etc., carried out, because if left to decay in the field they will infect the crop. Probably the most practicable method of disposing of these culls is to feed them to hogs, since stable manure should not be used on melon fields in any case on account of wilt. The carts used for hauling should be washed subsequently with a 2 per cent solution of bluestone.

Spray for anthracnose.—The methods advised for anthracnose control on page 8 will be helpful against stem-end rot, as the fungus which causes the latter disease does not attack a healthy melon vine, but will grow on leaves and stems killed by anthracnose and thence be carried to the melons.

Harvesting methods.—The cutters must never touch or cut into a decayed melon. Knives may be disinfected in a 2 per cent formalde-

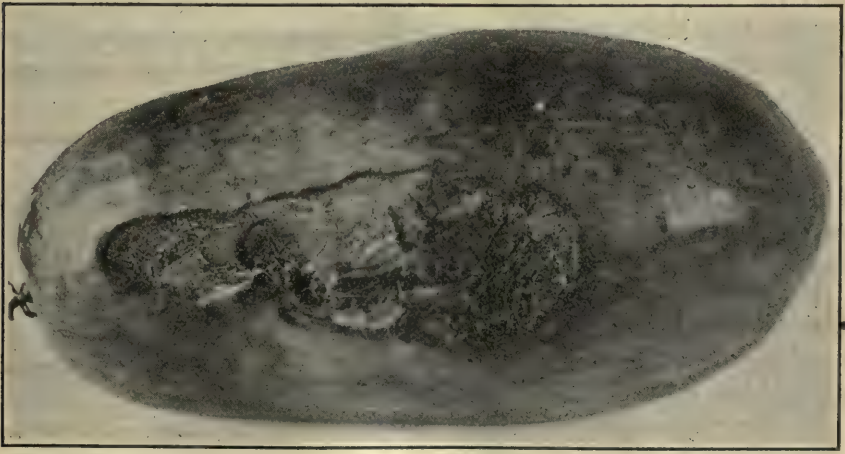

FIG. 11.—Watermelon injury attributed to contact with fertilizer on car walls, subsequent bruising, and the entrance of fungi.

hyde solution. Have the melons cut with the longest possible stems, as it takes longer for the fungus to grow up a long stem and it makes the second cutting at the car easier. Haul the melons to the car without delay. Fruits left in the fields until the next day may become infected in spite of the treatment. Handle carefully to avoid breaking or splitting the stem and to avoid bruises. Open the car ventilators, as this tends to better keeping. See that the bedding is dry, as melons loaded on wet bedding are more liable to decay.

Stem treatment at the car.—Since it is unlikely that all infection can be prevented by field sanitation, the most important control measure is the disinfection of the stem at the time of loading the car, using a paste that will adhere and for the quantity used be nonpoisonous and practically invisible. Such a material is starch paste with bluestone. It may be prepared in 1-gallon lots as follows, using a kettle of sufficient size of enamel ware, as the bluestone attacks iron or tin: Place 3½ quarts of water and 8 ounces of bluestone in the kettle and bring the mixture to a boil over a good fire. While it is heating, mix 4 ounces of starch with 1 pint of cold water, stirring until a milky solution free from lumps is obtained. As soon as the bluestone is entirely dissolved and the solution boiling, add the starch mixture, pouring it in a slow stream and stirring the hot solution vigorously to prevent the formation of lumps. Continue boiling and stirring the mixture until the starch thickens evenly. It may be tested at intervals by allowing it to run from the end of the paddle. This should not require more than one or two minutes' boiling after the addition of the starch.

The paste seems to be more readily applied when made up fresh, but if it is desired to make up a quantity at one time it may be depended upon to keep a week or two by using only one-fourth to one-half the proportion of water previously specified and then diluting the resultant thicker paste to the proper consistency as needed for use. Quart glass fruit jars with glass or enamel lined tops make convenient containers.

Where conditions require the use of a disinfectant paste made up in advance or bought in the market, a neutral commercial Bordeaux paste will be effective and convenient, as these are purchasable in small containers. Thin with water to the consistency of paint and apply with a brush in the same manner as the starch paste.

It is recommended that this be applied at the car, for experiments with stem treatment in the field were less effective because the handling rubbed off the paste or split the stem. The following method has proved to be practical and effective.

As the melons are packed in the car, have the stem ends turned outward while a second man or boy with a sharp knife cuts off a portion of the stem and applies a dab of paste to the fresh surface.

One man can accomplish this treatment without interfering with the speed of loading and can keep up with two packers. A quart of paste, costing only a few cents, will be needed for each car. To this expense must be added the labor cost of one boy or man for the number of hours required to load the car.

Car disinfection.—When freight cars have contained decayed melons or yard refuse they should be cleaned and disinfected before reloading with melons. For this purpose a 2 per cent solution of bluestone, applied with a spray pump to the interior walls, ceiling, and floor, will be found satisfactory. Five gallons will be required and the time of two men for 20 minutes.

MINOR DISEASES.

The wilt, root-knot, anthracnose, and stem-end rot already described are the only diseases which influence in a large way the culture of watermelons. Some other troubles, however, are met with occasionally, and these may be mentioned briefly.

Stem blight,[1] a fungous disease, produces an effect somewhat resembling wilt, but the vines tend to die from the center outward and diseased areas are visible on the stems, often with a gummy reddish exudate. Pull and burn diseased vines.

Bacterial wilt,[2] a serious trouble of cucumbers, occasionally attacks watermelons. The great majority of cases of wilt in watermelons, however, are of the Fusarium type described on page 4. The outward effects of the two diseases are much alike, but if one cuts the freshly wilted stem and on touching the finger to the exudate finds that it can be drawn out into fine mucilaginous strands, it may be concluded that bacterial wilt is present. Advice concerning remedial measures for bacterial wilt will be supplied by the Department of Agriculture upon application.

Downy mildew,[3] a leaf disease producing an effect similar to anthracnose, sometimes occurs, though it is more especially a cucumber trouble. Downy mildew does not attack the fruit. It is controlled by the spraying measures advised for anthracnose.

Malnutrition produces a leaf spotting distinguishable from anthracnose in that the spots are lighter brown and are located around the leaf margins and between the veins. This trouble is attributed to a lack of potash, but has not been sufficiently studied on watermelons to justify recommendations for preventing it during the present period of potash shortage.

Blossom-end rot is very common in most fields, but has been little studied. It seems to begin with an imperfect fruit, possibly due to defective pollination. Such culls are later invaded by decay-producing fungi. The Diplodia of stem-end rot is perhaps the most common, but other fungi also occur. Control measures consist in the prompt destruction of culls, to get rid of infection.

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[1] *Mycosphaerella citrullina* (Sm.) Gr.

[2] *Bacillus tracheiphilus* Erw. Sm.

[3] *Peronoplasmopara cubensis* (B. and C.) Clint.

Ground rot, so called because it begins on the side of the melon next to the soil, is due to a fungus very common in the South,[1] which is characterized by an abundant growth of white mold and the formation of numerous roundish, brown bodies the size of buckshot. This decay begins in some crack or in insect injury. The only control measure to be taken is the destruction of the affected fruits. A large number of other vegetables and cultivated plants are attacked by this parasite.

SUMMARY OF CONTROL MEASURES.

Loss from *wilt* is avoided by planting on land not previously used for watermelons, with precautions against the use of infected stable manure and spread by drainage water and live stock.

Losses from *root-knot* can be prevented by the use of land free from infestation by this pest.

Anthracnose is controlled by thorough spraying with Bordeaux mixture during the month preceding the maturity of the crop.

For *stem-end rot* the most important measure is the disinfection of the cut stems as the melons are being loaded into cars.

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[1] *Sclerotium rolfsii* Sacc.

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LIVE-STOCK CLASSIFICATIONS AT COUNTY FAIRS

S. H. RAY
Animal Husbandry Division

FARMERS' BULLETIN 822

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

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Division of Publications, U. S. Department of Agriculture

ONE of the principal objects of a live-stock exhibition is to bring before the stockmen and the public a standard of excellence toward which all may strive in the improvement of domestic animals. The educational value of such an exhibition will depend largely upon two things, namely, the classification of the animals to be exhibited and the judgment of the official who passes upon the merits of the exhibits. The two are absolutely dependent upon each other in presenting the lessons which the exhibition should teach.

The classification of live stock used at many of the county fairs is such that it is of little instructive value to the public and often causes criticism alike of the judges and of fair officials. As an example, the following class is not uncommon: "Best aged stallion, any breed." In this case all aged stallions, regardless of whether they are of the pony type, saddle type, light-harness type, or draft type, are brought into competition without any qualifications whatever. Should a pony stallion be placed first, a saddle stallion second, and a draft stallion third, there is sure to be confusion in the minds of the audience and criticism of officials. Each class at a live-stock show should represent a definite type of animals which have some definite function or purpose.

It is hoped that this publication will aid very materially in standardizing the classifications at county fairs and that it will be of assistance to fair officials and prospective exhibitors.

LIVE-STOCK CLASSIFICATIONS AT COUNTY FAIRS.

CONTENTS.

	Page.		Page.
Educational value of live-stock exhibitions	3	Announcement of judges, prize winners, etc.	6
Cooperation with live-stock organizations	3	Exhibition of prize winners	6
Uniformity of classification	4	Rules	6
Special features	4	Premiums	7
Selection of superintendents, judges, etc	5	Classifications	8
Arrangement of exhibits	5		

EDUCATIONAL VALUE OF LIVE-STOCK EXHIBITIONS.

THE chief value of live-stock exhibitions or shows, whether under the auspices of community, county, State, or larger organizations, lies in their educational features. Live-stock shows and fairs have been an important factor in the improvement of farm animals, since it is the show ring which designates the types and standards that breeders of animals strive to produce. These standards generally are based on market and economic demands.

The absorbing interest of competition in the show ring stands as the chief incentive for the breeder to exhibit his animals. If he annually enters into competition with other breeders, he will surely improve the quality and type of his herd or flock. The great value of the live-stock show ring for the less experienced breeder, however, is in the demonstration of standards which may be followed. The best qualified persons obtainable are found officiating as judges at the large exhibitions. These men know the requirements for the animals which they judge, and through them breeders become better acquainted with the standards for the breed in which they are interested and also with the faults and good points of their own exhibits.

While the chief value of exhibitions is educational, the live-stock exhibits at county fairs are often so poorly classified that frequently the educational value is largely lost. It is the purpose of this bulletin to discuss in a general way some of the factors which, if properly handled, will help to increase the value of the county live-stock exhibit.

COOPERATION WITH LIVE-STOCK ORGANIZATIONS.

The county fair officials should enlist every aid possible to make the live-stock show a success. To be successful it must by all means have the backing of the breeders of the county, and of other counties if possible. Cooperation with the county live-stock association, if such an organization exists, and with the county agricultural agent is essential. If the live-stock association advocates a certain kind of breed of live stock, then the officials should provide liberal prizes for such classes. In a great many cases it will be advisable for the county fair officials to meet with the county live-stock association before the premium list and classification are announced. In most instances it would be well to allow the association the privilege of offering suggestions in making up the premium list and classification. In this way their interests will be represented and their support consequently will be stronger.

UNIFORMITY OF CLASSIFICATION.

The county fair classification should be uniform from year to year and, as far as possible, the classifications of different county fairs in the same State or section should be uniform. County fair secretaries should be careful that their show dates do not conflict with those of neighboring counties. To provide for uniformity in classifications, to arrange fair dates, and for other purposes an association composed of the county fair officials in the State is very helpful. Such organizations generally meet once a year for discussion. A good place and time for this meeting is at the State agricultural college during some farmers' meeting.

SPECIAL FEATURES.

The county fair secretary can introduce many features which will tend to make the live-stock exhibit better each year. He should by all means endeavor to have some special feature with a good-sized purse so as to stimulate discussion and create enthusiasm. The following brief mention of two such features may be useful.

FUTURITY CONTESTS.

One very effective feature which may be adopted is the futurity contest. In this the breeder names the animal which he will exhibit soon after or even before it is born; in case it is not yet born, the dam of the animal is named. In this contest, each breeder entering should be required to put up a sum of money which is to go into the general purse. He may be required to put up another sum just before the date of the fair, and at some shows the exhibitor is required to pay still another fee at the time of the actual contest. The amount required from each exhibitor should not be too great; but the nomination fee, even though it be small, is essential for the success of the futurity contest. All the money received through the nomination of animals is put into the general purse, which may be divided into three or more prizes. Generally the fair association adds additional money to the purse. The more money in the purse the keener the competition. The animals nominated are judged during the fair week just as are the other classes.

Full information concerning futurity contest rules may be obtained from the secretaries of different State fairs and from the secretaries of live-stock breeders' associations.

JUDGING CONTESTS.

The live-stock judging contest for boys and girls is a feature which always draws interest and helps to enlarge the attendance at the county fair. In such a contest teams from different districts or from different schools may compete against one another or the contest may be for individuals. The former is the better method, since the outside interest will be greater. School teachers should be encouraged to enter teams, and with the assistance of the county agricultural agent may train the teams or individuals for the contest. The teams generally are composed of five contestants. Both team and individual prizes should be given. The county agent, agricultural college officials, or other competent persons may be called upon to help in drawing up the rules of such a contest and to help train the contestants and manage the contest.

SELECTION OF SUPERINTENDENTS, JUDGES, ETC.

The fair officials should select capable men to act as superintendents of the different kinds of live stock. It is better that these should be prominent local live-stock men, and, if possible, the same men should act each year.

In choosing the judges only men of known ability should be selected. These men should have had special training and experience along such lines. In most States the agricultural colleges will furnish competent judges. If the judges do their work well they should not only place the classes correctly, but should explain to the exhibitors and the audience after each class is placed why the animals were so placed. The advantage of having men with special training as live-stock judges is that such men can give in detail the reasons for the placing of each class, which is a feature that should not be overlooked.

ARRANGEMENT OF EXHIBITS.

Nothing so adds to the attractiveness of a live-stock exhibit as good arrangement supplemented with liberal placarding. The different kinds of live stock should be in separate divisions and the different breeds should also be kept separate. Each barn or section should be marked with a large sign, such as "Beef cattle," "Sheep," "Horses," "Swine," "Dairy cattle," "Poultry," etc., denoting the kind of live stock in each. The location of each breed should be plainly marked also, and the exhibitors would be performing a great service if they would put up a placard before each animal indicating its sex, breed, name, sire, dam, age, weight, etc. Fair secretaries are overlooking a very important feature when they fail to see that this is done. In some instances it would be well to offer prizes to the exhibitor with the best kept and best placarded exhibit.

After the animals have been judged they should be kept unblanketed for a specified time each day, weather permitting.

ANNOUNCEMENT OF JUDGES, PRIZE WINNERS, ETC.

A suitable board should be erected in the judging arena and on this board should be posted the name of the officiating judge, the breed being judged, the catalogue number, etc., of the class which is being judged, and also the winners in the previous class. The interest in the judging will be much greater if this information is given. If a program is printed, there should be placed in a conspicuous position on each animal or on the attendant a number which corresponds with the program or catalogue number. In announcing the prize winners on the bulletin boards, if programs are printed and distributed, the numbers may be announced instead of the names.

EXHIBITION OF PRIZE WINNERS.

A live-stock parade always attracts much attention and interest and in all cases should constitute a portion of the regular program. When possible a short talk by the live-stock judge or judges concerning each of the prize-winning animals and a few of those that did not win would be highly appreciated by the audience. Such features have great educational value, but few fairs take advantage of such opportunities.

RULES.

The rules governing a live-stock exhibition should be as few and as explicit as possible. Too many rules and rules which can not be enforced are worse than none at all. There are some, however, governing certain points which should be made. A few such rules are as follows:

1. The final date for entering should be announced, and no entries should be received after this date.

2. The time at which each class is to be shown should be announced and the program should be followed explicitly. Nothing so disgusts an audience as to sit and wait for a feature which does not appear according to the announced schedule.

3. After arrival at the show grounds all entries are under the supervision of the fair officials, live-stock superintendent, etc., and no animals should be allowed to leave the grounds without special permission. The live-stock superintendent has the right to call out any or all animals for parades or other special purposes. Other officials may exercise this privilege only through the superintendent of live stock.

4. The live-stock superintendent and the fair officials (the latter acting through the former) have the right to determine whether or not an animal may compete in any class, and the superintendent should verify the ages of all entries, their registration papers, health, etc.

5. The placings made by the judges are final unless protested in writing, and all protests should be made within a limited time and should be accompanied by a stipulated sum of money which is forfeited in case the protest is not sustained.

6. No barren animals should be permitted to compete in breeding classes, and the following rules may be used in governing this point:

(*a*) All cattle 3 years old or over entered in the breeding classes must have produced living progeny within 18 months of the first day of the exhibition.

(*b*) All swine 2 years old or over entered in the breeding classes must have produced living offspring within 12 months prior to the date of exhibition.

(*c*) All horses 5 years old or over entered in the breeding classes must have produced offspring within 18 months previous to the date of the show. This also applies to jacks and jennets.

7. All males 1 year old or over entered in the breeding classes should be registered. Females 1 year old or over should be registered, except in cases where grades are permitted to compete in the breeding classes. This rule should be followed in all cases. Breeders should be required to show their registration papers on demand of the fair officials.

8. Animals shown in breeding classes should not be permitted to show in fat classes.

PREMIUMS.

The division of the money offered as prizes depends upon the amount of money available for all prizes and upon other conditions. Ordinarily the prize money at county fairs on each class is divided into three premiums. In cases where three prizes are offered, the money is often divided in the proportion of 3–2–1. If only two prizes are given the proportion of 3 to 2 is suitable.

Nicely lettered ribbons should also be given. The colors generally used are blue for first prize, red for second, white for third, and royal purple for champions. In nearly all cases the ribbon is sufficient for champion animals. This enables the county-fair officials to give more money on the remainder of the classifications.

Some of the classifications suggested later do not contain classes for certain groups of animals commonly shown at large fairs. While prizes for such classes have a value where competition is strong among professional breeders, it is believed that smaller fairs can give more encouragement to beginners and small breeders by using most of the money offered on a breed for increasing the number and value of prizes in the single classes.

At some fairs sweepstakes prizes are given. This involves the showing of animals of different types or breeds, as beef and dairy animals, in the same class. The placing of such classes very seldom gives satisfaction, and under no conditions is such a classification advisable.

CLASSIFICATIONS.

The following classifications are general and can be varied to suit local conditions. It must be kept in mind, however, that animals which are of different types—that is, used for different purposes—should not be classified or shown together. The light breeds of horses should not be shown with the draft breeds, the lard type of swine with the bacon type, etc. These are common errors of county fair classifications. If the number of animals exhibited is small, the different breeds of the same type of animals may be shown together, such as the breeds of mutton sheep, the breeds of beef cattle, etc., and, if necessary, the classification by ages may be reduced.

BEEF CATTLE.

The ages of cattle should be dated from September 1. Thus, all cattle born after September 1 in any year may be shown in the under-one-year classes for the remainder of that year and during all the next year. Such cattle would then be shown in the under-two-year classes during the year following, and so on. If more prizes are to be given than is indicated in the classifications which follow, two classes may be made for the calves and for yearlings. These are known as the juniors and seniors. The juniors consist of all animals born between January 1 and August 31, and the seniors consist of all animals born between September 1 and December 31, inclusive. For instance, a calf born on September 1 of the present year and shown in the fall of next year would be a senior calf, while one born January 1 of next year and shown at the same time would be classed as a junior calf. The same dates hold for the junior and senior yearlings. There may be junior and senior classes for both bulls and heifers.

The classes for beef cattle which are given below are intended for pure-bred animals, with the exception of the classification indicated for fat animals. Only pure-bred bulls should be allowed to compete. If there are few pure-bred beef cows in the county and a larger number of good grade cows, it may then be advisable to offer prizes for grade beef cows, in which case the classification given for pure-breds may be used. This classification may be used for each breed:

Bull 3 years or over.
Bull 2 years and under 3.
Bull 1 year and under 2.
Bull under 1 year.
Cow 3 years and over.
Cow 2 years and under 3.
Heifer 1 year and under 2.
Heifer under 1 year.
Champion bull, any age (only first-prize winners to be shown).
Champion cow, any age (only first-prize winners to be shown).
Get of sire—4 animals got by same sire (sire need not be shown).
Herd—1 bull and 4 females; bull, 1 year or over; females any age.

FAT CLASSES.

At most county fairs all steers, pure-breds, grades, and cross-breds should be shown together. Spayed or free-martin heifers, and in some cases open heifers, should be allowed to compete with the steers.

Steer 2 years and under 3.
Steer 1 year and under 2.
Steer under 1 year.
Champion fat steer, any age (limited to first-prize winners in previous classes).

DAIRY CATTLE.

The ages of dairy cattle should be reckoned the same as those of the beef breeds. The same classification as indicated for breeding beef animals may be used for dairy cattle. In these classes only pure-bred bulls should be allowed to compete, but if there are not large numbers of pure-bred cows in the county all breeds may be shown together and grade cows may be admitted. If grades are shown, only those which are sired by pure-bred bulls should be admitted.

DUAL-PURPOSE CATTLE.

At some county fairs the dual-purpose breeds, such as the Red Poll and the milking Shorthorn, may be shown together. However, if sufficient numbers are available for separate classes, these breeds should be judged separately. The same classifications as indicated for beef and dairy cattle may be used for dual-purpose cattle unless conditions warrant changes.

SWINE, LARD TYPE.

The dates for computing the ages of breeding classes of swine are fixed as September 1 for senior classes and March 1 for junior classes. Generally it is advisable for the county fair to have both junior and senior classes for swine. The following classification may be used for each breed for which prizes are offered:

Aged boar 2 years and over.
Senior yearling boar over 18 months and under 2 years.
Junior yearling boar over 12 months and under 18 months.
Senior boar pig over 6 months and under 12 months.
Junior boar pig under 6 months.
Champion boar any age (limited to first prize winners in previous classes).

The same classification is used for sows, but in addition a prize may be offered for best sow and suckling pigs. Group prizes may be offered as follows:

Best herd—1 boar and 3 sows, any age.
Get of sire—4 pigs, any age, the get of 1 boar.

FAT CLASSES.

Pen of 3 fat barrows over 12 months.
Pen of 3 fat barrows under 12 months.
Champion pen barrows, any age.
Barrow over 12 months.
Champion barrow, any age.

SWINE, BACON TYPE.

The same classification as indicated for the lard type of swine may be used for the bacon type, but the two types should never be shown together.

SHEEP.

The ages of sheep date from January 1 except in the case of Dorset Horns, the age of which may be dated from September 1. All sheep showing should have been shorn after March 1 of the year in which they are shown. The following classification is suggested for each breed for which prizes are offered. If grade ewe classes are shown, they should be the same as for pure-bred ewes.

Ram 2 years or over.
Ram 1 year and under 2.
Ram under 1 year.
Ewe 1 year and under 2.
Ewe under 1 year.
Champion ram (only first-prize winners to be shown).
Champion ewe (only first-prize winners to be shown).
Pen of 3 ram lambs.
Pen of 3 ewe lambs.

FAT SHEEP.

Pen of 3 wether lambs.

GOATS.

Only a few county fairs in sections where goats are raised will have need for a classification of Angora or other goats. The one given here may be reduced or enlarged as conditions necessitate.

Buck 2 years or over.
Buck 1 year and under 2.
Buck kid (under 1 year).
Doe 2 years or over.
Doe 1 year and under 2.
Doe kid (under 1 year).
Champion buck (only first-prize winners to be shown).
Chamion doe (only first-prize winners to be shown).
Pen of 4 kids under 1 year, either or both sexes.

HORSES.

The ages of horses should be dated from January 1. All horses should be shown at the halter unless otherwise specified. Prizes offered for stallions should be for registered pure-breds only. In case grade mares are to be shown, the classification suggested for pure-bred mares may be used. Where there are but a few pure-bred mares in a community, pure-breds and grades may be shown together, in which case only those sired by pure-bred stallions should be allowed to enter. The following set of classes will serve for each breed shown:

ANY BREED OF HORSES SHOWN AT THE HALTER.

Stallion 4 years and over.
Stallion 3 years and under 4.
Stallion 2 years and under 3.
Stallion 1 year and under 2.
Mare 4 years and over.
Mare 3 years and under 4.
Mare 2 years and under 3.
Mare 1 year and under 2.
Foal under 1 year, either sex.
Mare and foal.
Champion stallion, any age (limited to first-prize winners).
Champion mare, any age (limited to first-prize winners).
Get of sire—4 animals by same sire—any age (sire need not be shown).

SPECIAL CLASSES (NO REQUIREMENTS AS TO BREEDING).

Light harness stallion, mare, or gelding, any age, shown to proper vehicle.
Heavy harness stallion, mare, or gelding, any age, shown to proper vehicle.
Pair light harness horses, any age, shown to proper vehicle.
Pair heavy harness horses, any age, shown to proper vehicle.
Combination stallion, mare, or gelding, to be shown in harness, unharnessed, and saddled in the ring, and to show 5 distinct saddle gaits.
Three-gaited saddle stallion, mare, or gelding.

JACKS.

All jacks entered in these classes should be registered.

Jack 4 years and over.
Jack 3 years and under 4.
Jack 2 years and under 3.
Jack 1 year and under 2.
Jack under 1 year.
Champion jack.
Get of sire—4 mules by same jack, any age (sire need not be shown).

The same classification may be used for jennets.

MULES.

Mule 4 years or over, either sex.
Mule 3 years and under 4, either sex.
Mule 2 years and under 3, either sex.
Mule 1 year and under 2, either sex.
Mule under 1 year, either sex.
Champion mule.
Span mules hitched to wagon.

PONIES.

Pony stallion, any age.
Pony mare, any age.
Pony foal, either sex.
Pony in harness.
Pair ponies in harness.
Pony under saddle, any age.

POULTRY.

Secretaries of fair associations, in preparing the poultry classifications for their premium lists, are requested to use the classification as shown in the American Standard of Perfection, which is published by the American Poultry Association. This also should be the guide used by all judges when placing awards on poultry.

For single entries the classification should be cock, hen, cockerel, and pullet, and the different ages should be judged separately. The classification also can be made to include pairs, trios, and pens of old and young birds, the old and the young birds competing separately.

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2nd.

SUGAR-BEET SIRUP

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FARMERS' BULLETIN 823

UNITED STATES DEPARTMENT OF AGRICULTURE

Joint Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief
and the Bureau of Chemistry, Carl L. Alsberg, Chief

Washington, D. C. May, 1917

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Division of Publications, U. S. Department of Agriculture

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THIS BULLETIN tells how to grow sugar beets in the garden and describes a simple process of making from them a palatable and nutritious table sirup with a pleasant flavor. A patent for the process of making the sirup has been issued to the authors of this bulletin for the benefit of the public, so that any one is free to use it. Tests by farmers as well as the Department have proved the process to be practicable.

Sugar beets may be grown in any locality which has tillable soil that is capable of producing good crops of vegetables. A small piece of ground is sufficient for planting a few rows of beets—enough to furnish the family with sirup. The tools needed are necessary in almost any garden operation—a spade, a hoe, and a rake.

All sugar beets, if properly handled, will produce sirup. The beets are cut into thin slices and soaked in hot water to extract the sugar. The liquid is then boiled down to the thickness desired. Detailed directions are given in the following pages.

SUGAR-BEET SIRUP.

CONTENTS.

	Page.		Page.
Growing sugar beets for sirup	3	Making sirup from sugar beets	9
Selecting the land	3	Preparing the roots	9
Preparing the seed bed	4	Extracting the sugar	11
Planting the seed	5	Boiling the juice	11
Caring for the plants	6	Skimming	12
Harvesting the roots	6	Quality of the sirup	12
Storing the roots	7	Uses of beet sirup	13
Sugar-beet seed	8		

GROWING SUGAR BEETS FOR SIRUP.

THE production of beet sirup consists of two distinct operations: (1) The growing of the raw material, the beets, and (2) the making of the sirup.[1] The sirup making embraces two essential operations, the extraction of the juice from the roots and the reduction of this juice to the desired consistency.

Sugar beets may be grown and sirup produced in any locality which has tillable soil capable of producing good crops of vegetables. Therefore, anyone having a small piece of fertile, tillable ground and the usual garden implements, a spade, a hoe, and a rake, is equipped to grow the beets necessary for the production of a home supply of sirup. In some localities the beets produced are richer in sugar than they are in other localities, but all sugar beets, if properly handled, are capable of producing sirup. The richer the roots are in sugar, the larger the quantity of sirup that may be produced from a given quantity of roots and the less the time that will be required to reduce the juice to the desired consistency.

To those who are not familiar with the growing of sugar beets the following brief directions and suggestions may be helpful.

SELECTING THE LAND.

The ground selected for growing the beets should be well drained and fairly fertile. Extremely poor, shallow, sandy, or hard soil should not be used for beets until it has been put in proper condition for crop production; likewise, ground that has been very heavily manured should be avoided, since such soil sometimes produces very large roots, poor in sugar. A few rows of sugar beets in the garden will generally be sufficient for a supply of sirup for home use. A bushel of beets will produce from 3 to 5 quarts of sirup, as indicated in the illustration on the title-page. Beet roots when mature should weigh from 1 to 2 pounds each; hence, 30 or 40 average beets will make a bushel. These facts will enable one to estimate the area that will be needed to produce the home supply of sirup.

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[1] A patent for this process of making sirup from sugar beets (patent No. 1155806, Oct. 5, 1915) was issued to the authors of this bulletin, H. C. Gore and C. O. Townsend, U. S. Department of Agriculture. Tests of the process were made by farmers under the direction of Mr. William H. Burns, of the Office of Sugar-Beet Investigations, assisted by Mr. Charles G. Crawford, a collaborator in the same office.

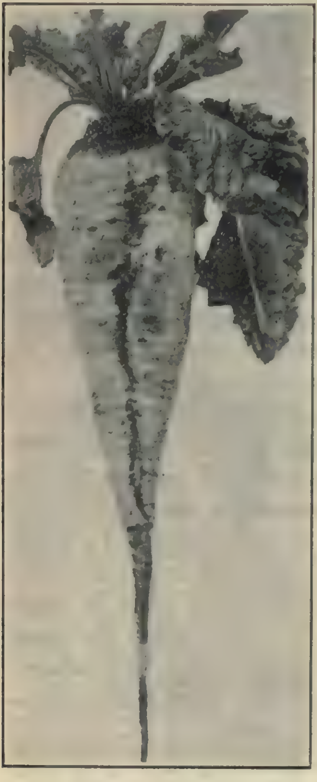

FIG. 1.—A beet root of good shape.

If more beets are grown than are necessary for the sirup supply, it should be borne in mind that they are excellent for the table. When partly grown the entire plant may be used as greens, and when mature the roots may be cooked and served like garden beets. All sugar beets are white, but when properly grown they are generally much richer in sugar than the garden beet and just as tender. Sugar beets, either raw or cooked, are excellent feed for chickens, hogs, and other live stock.

PREPARING THE SEED BED.

Having selected a suitable place for growing the beets, the ground should be plowed or spaded to a good depth, remembering, however, that too much raw soil should not be brought to the surface at one time. The reason for a deep root bed for sugar beets is apparent from the shape of the root, as shown in figure 1. The ground should be plowed or spaded in the fall, but good results may be obtained by doing this work in the spring provided the ground previously has been in good tilth. As early in the spring as conditions will permit the ground should be harrowed or raked until it is firm, smooth, and free from lumps. The surface soil should not be too fine, especially in those sections where high winds are expected during the early summer. The ground should be kept free from weeds, but should never be worked when too wet. The proper time, always, for working the ground is when it is friable; that is, when it falls apart readily when handled.

PLANTING THE SEED.

Sugar-beet seed usually may be obtained, at least in small quantities, from the large seed dealers. A pound of seed will plant one-tenth of an acre if the work is done carefully. Usually a few ounces of beet seed will produce a quantity of beets sufficient for sirup making and for table use for the average family. The seed should not be planted until the ground is warm and the other conditions right for quick germination and for the subsequent growth of the plants.

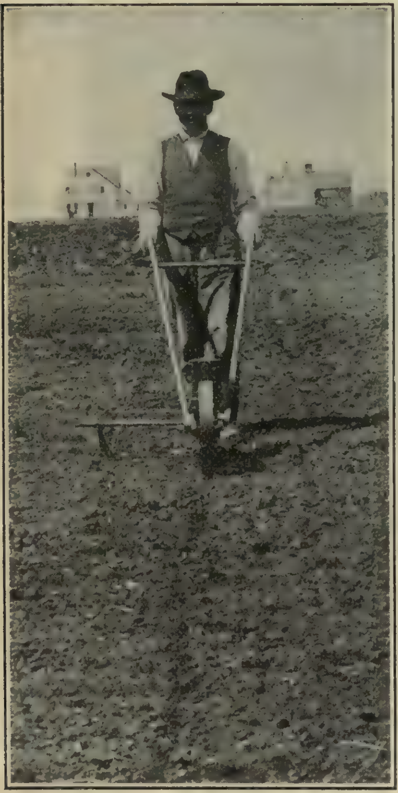

FIG. 2.—A garden seed planter.

FIG. 3.—Blocking sugar beets.

Sugar-beet seed should be planted in rows about 20 inches apart and may be dropped either in continuous rows or in hills. If planted in hills each hill should contain from three to six seed balls, and the hills should be about 10 inches apart; if planted in solid rows the plants should be blocked in the manner described below as soon as possible after they are up. The seed should be covered to a depth of one-half inch to 1 inch. The covering should be as shallow as conditions will permit; that is, it should not be so thin that it will dry out and leave the seed without sufficient moisture for germination, and it should not be so thick that the young plants can not readily get through to the light.

In growing sugar beets commercially the seed usually is planted with a 4-row drill designed especially for the purpose. In planting small lots of beet seed for sirup making, a garden planter of any of the usual makes, as shown in figure 2, will be found satisfactory. These planters can be set so that they will plant seed either in solid rows or in hills. In case a planter is not available, an area sufficient for sirup-making purposes can be planted easily by hand. In this case a shallow furrow may be made with a rake handle or other convenient implement and the seed dropped by hand and covered by using the back of the rake.

CARING FOR THE PLANTS.

As already indicated, the seed should be planted in solid rows or in hills. When in solid or continuous rows the plants should be blocked. Blocking consists in cutting out with a hoe or other implement a part of the plants so that the remaining beets stand in tufts about 10 inches apart. In blocking the beets, the direction of the stroke should be at right angles to the row, as shown in figure 3. As soon as the plants are large enough to be handled conveniently, they should be thinned to one plant in each hill or tuft. This operation must be done by hand, since the plants in the hills or tufts stand very close together. The plants should be cultivated and hoed from time to time, in order to keep down all weeds and to furnish the best possible conditions for growth.

If the natural water supply is not sufficient, the beets should be irrigated when they show signs of needing moisture for their proper growth and development. If the beets wilt during the day and fail to recover at night, they should be watered. In case of irrigating, a furrow should be made several inches from the beet row and the water should be allowed to run down this furrow until the ground is thoroughly wet. In no case should the surface of the ground around the beets be flooded, since flooding often causes a crust to form around the beet, cutting off the air supply from the root and thereby retarding the growth of the plant. From one to three irrigations should be sufficient in most sections where the rainfall is not abundant enough to produce satisfactory beets.

HARVESTING THE ROOTS.

In most sections of the country from four to six months are required for the beets to reach their proper size and stage of development. The proper stage for harvesting will be indicated by a yellowish tinge of the foliage and by the fact that the beets when pulled leave the ground almost free from dirt, as shown in figure 4. If the patch of beets is large the roots should be loosened by means of a so-called lifter, of which there are two kinds, the double-pointed and the side lifter. The latter is similar in appearance to a subsoil plow and is operated alongside the beet row, loosening the beets without breaking them. The plants then can be pulled and thrown into piles or rows.

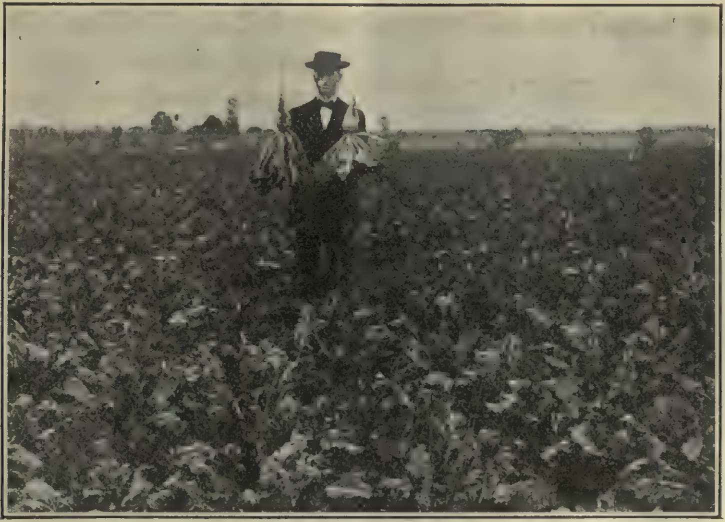

FIG. 4.—Field sugar beets, the kind to be grown in the garden for sirup making.

If the patch of beets is small and a lifter is not at hand, the beets may be loosened by means of a spade or a 2-tined lifting fork and thrown into piles. The beets should then be topped by cutting them off squarely at the point where the lowest leaf was attached. The topping can best be done by means of a heavy knife; usually a single stroke is sufficient to top a beet. The roots can then be made into sirup at once, or they may be stored until a more convenient time.

STORING THE ROOTS.

The roots may be stored either on the surface of the ground or in a pit or a cool cellar and kept for several months. The following suggestions will be helpful in storing beet roots, either for sirup-making purposes or for seed production. The simplest and least expensive method of storing the roots is to throw them into a pile on the surface of the ground, selecting for this purpose a well-drained spot. Dirt should then be thrown over the pile until it is almost or completely covered. If the weather is mild, the top of the pile should be covered very lightly or left entirely open for a few days until the roots have passed the heating stage. As the weather gets colder more dirt should be added, to prevent the roots from freezing and to keep them from wilting.

The second method, namely, the pitting of the roots, is accomplished by digging a hole or pit in a well-drained place, the size of the hole depending upon the quantity of roots to be stored. The roots should then be placed in the hole and the surface covered with dirt, lightly at first, and the covering increased as the weather gets colder. If the beets are stored in a cellar they should be packed in moist sand or covered with sand or dirt to keep them from wilting. The two points to be kept in mind in storing beet roots are (1) to keep the roots cool without letting them freeze and (2) to keep them from wilting. They will work up much better if they are kept fresh and crisp, although the wilting does not materially change their quality.

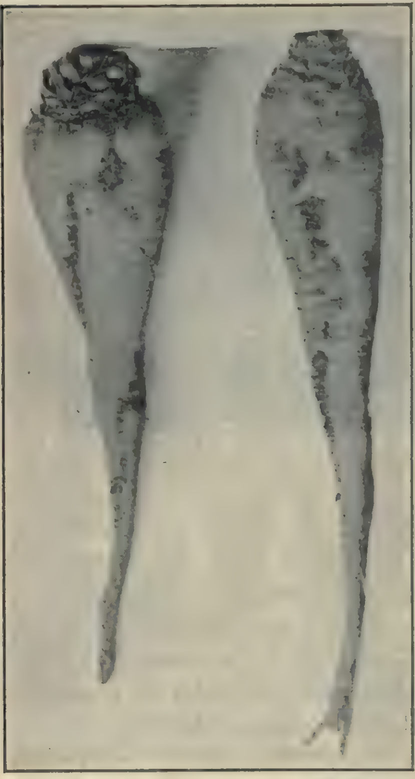

FIG. 5.—Beet roots for seed. Roots saved for seed should have the leaves removed without injuring the crown.

SUGAR-BEET SEED.

Those who are interested in the making of beet sirup from year to year, especially in the cooler portions of the United States, may grow their own seed if they so desire. Just how long seed can be produced in this manner without serious reduction in the quality of the roots has yet to be determined. However, the indications are that at least several generations of beet plants may be produced without reducing the quality of the roots too low for sirup-making purposes. Two growing seasons usually are required for the production of sugar-beet seed from seedling plants. It is necessary, therefore, that the beets produced the first season be gathered in the fall and stored in the manner described above. In case the beets are to be used for seed production they should not be topped, but the leaves should be removed either by twisting them off or by cutting them off with a sharp knife without removing or injuring any part of the crown, as shown in figure 5. In this condition the beets should be stored until spring. They should then be planted in a well-prepared root bed just as early as weather and soil conditions will permit. The early planting of the roots seems to be an important condition in beet-seed production.

The planting may be done by thrusting a long spade into the earth; the spade should then be pushed forward, the root crowded down back of the spade, as shown in figure 6, and the spade withdrawn. The dirt should then be packed around the root, the crown of which should be flush with or slightly below the surface of the soil, so that the crown is covered with a thin layer of dirt. A light covering over the crown seems to be of advantage in preventing it from drying out, and it also is a protection against late frost. The roots should be well supplied with moisture during the entire growing season, irrigating them if necessary, especially when the seed is forming. When the seed is ripe, it may be gathered by pulling it from the seed stalks by hand. The habit of growth of the seed stalk, shown in figure 7, indicates how easily the seed may be gathered. It should be spread in a suitable place to dry, after which it is ready for the next year's planting. No artificial heat should be used in drying the seed. Each plant should produce from a few ounces to a pound of seed; hence, a very few roots will be sufficient to furnish the ordinary family with an abundant supply of seed.

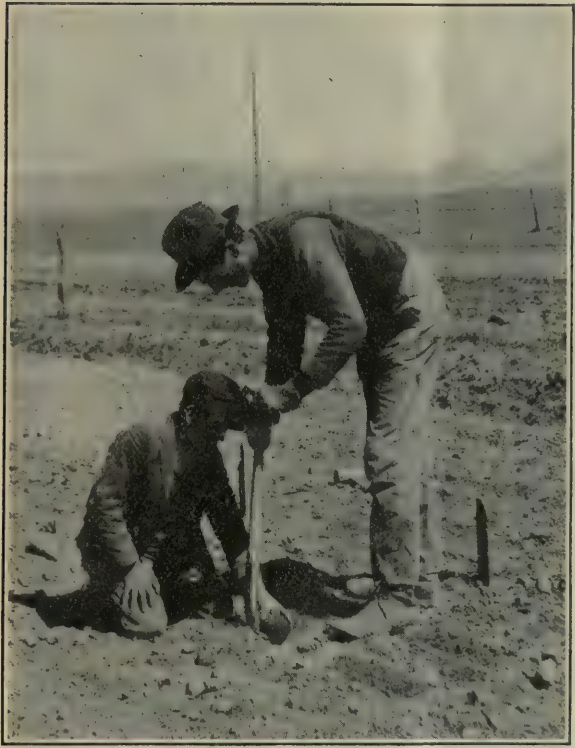

FIG. 6.—Planting beet roots for seed.

MAKING SIRUP FROM SUGAR BEETS.

PREPARING THE ROOTS.

The first step in making beet sirup consists in topping and cleaning the roots. As already stated, the crowns should be cut off at the point of the lowest leaf scar. The reason for this is that the crown or upper part of the beet contains a large part of the salts taken from the soil in the process of growth. It is desirable to have the sirup as free as possible from these mineral salts which, if present in too large quantities, would render the sirup unpalatable.

In cleaning the roots, they may be placed in a tub or other suitable receptacle and covered with cool water, to loosen the dirt and to make the roots more crisp. After soaking for a few minutes, until the dirt is loosened, they should be thoroughly scrubbed. A coarse brush with stiff bristles or wire is useful in this work. After the roots are thoroughly washed they should be cut into thin slices. A 3-bladed kraut cutter securely fastened on the top of a barrel, as shown in figure 8, has been used in field experiments and found very satisfactory. The upper head of the barrel should be removed,

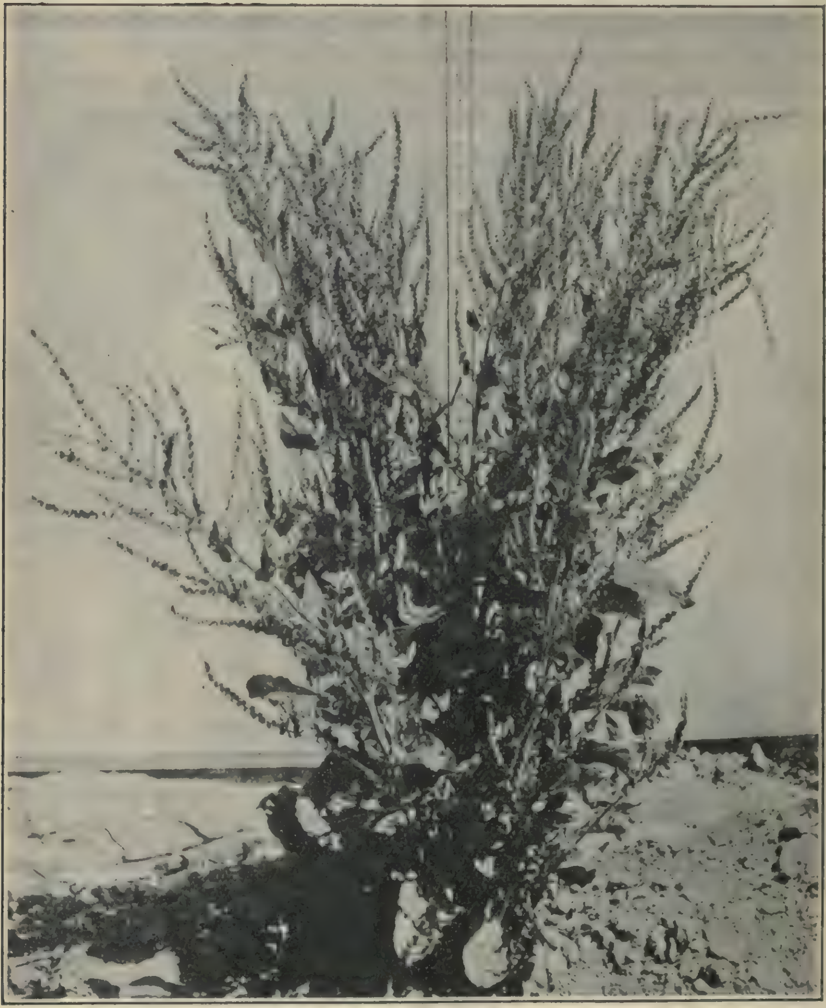

FIG. 7.—A common type of beet seed stalks.

so that the beet slices will fall directly into the barrel. If a kraut cutter is not at hand, any slicing device, the simplest of which is a butcher knife, will be satisfactory. The slices should be very thin. The thinner the slices the more rapidly the sugar is extracted. In field experiments slices only one-sixteenth of an inch in thickness were obtained. The slicing box of the slicer was not used, the beet root being held in the hand and pressed against the blades of the slicer.

EXTRACTING THE SUGAR.

A bushel of beets will make approximately 2 bushels of slices, which should be placed in a barrel and covered at once with hot water. About 10 gallons of water will be required to cover them. An excess of water should be avoided, since it would increase the amount of evaporation required to reduce the solution to the desired consistency. If boiling water is used, the temperature of the slices will reduce the temperature of the water to about the proper degree, from 70° to 80° C. (158° to 176° F.), for the extraction of the sugar. The barrel should be covered with several thicknesses of canvas to hold the heat. The sliced beets should be permitted to soak for about 60 minutes, and the barrel should be agitated from time to time without uncovering it.

The water should now be drawn off and strained through several thicknesses of cheesecloth. No pressing is required to remove the juice from the beet. If the barrel is provided with a faucet near the bottom for the purpose of drawing off the liquid, it will be found convenient. The soaking does not remove all the sugar from the beet slices, but by far the larger part of it is extracted if the slices are sufficiently thin and the water is of the proper temperature. The resulting liquid is of a light-brown color, with a sweetish bitter taste. The refuse beet slices are a valuable feed for chickens, hogs, and other live stock.

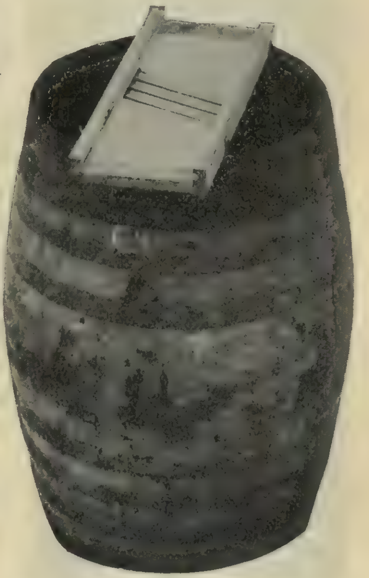

FIG. 8.—Barrel with upper head removed and kraut cutter securely fixed in place.

BOILING THE JUICE.

The juice may be placed in a kettle or other convenient receptacle, where it should be heated slowly until it has evaporated to the proper consistency. It should be noted that evaporation depends upon the temperature, the surface of the liquid exposed, and the condition of the air above the liquid. In experiments made by the writers a 30-gallon copper kettle was used. Slow boiling is important in making beet sirup, and several hours will be required to complete the evaporating process. This may be done on the kitchen stove, or a kettle may be suspended in the open, as shown in figure 9, and fire should be maintained sufficiently hot to keep the liquid boiling until the proper amount of evaporation has taken place to produce the desired consistency of sirup. Some people like a thin sirup, while others prefer a thick product. In boiling the juice, care should be taken to avoid burning. A little experience will enable one to accomplish the boiling without scorching the sirup.

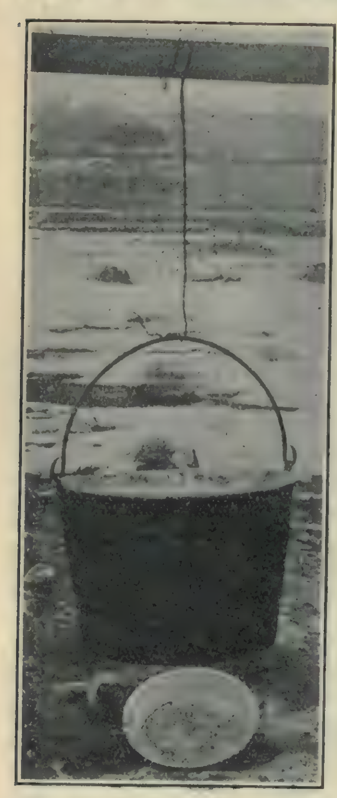

FIG. 9.—Kettle used in demonstrating beet sirup making on the farm.

SKIMMING.

While the boiling is progressing, a scum will rise on the surface of the liquid; this should be removed carefully by means of a skimmer. An old-fashioned milk skimmer, or a basin with or without small holes in the bottom, will accomplish the desired result. The skimmer should, for convenience, be provided with a suitable handle. A small straight or curved stick of proper length, split at one end and slipped over the edge of the skimmer, will serve the purpose. The object in skimming is to remove the scum as completely as possible without wasting any of the liquid. This operation removes the strong, beetlike flavor and leaves a wholesome and palatable product. The removal of the scum tends also to keep the liquid from boiling over. As soon as the sirup has reached the desired consistency and has been skimmed carefully it may be placed in cans or bottles for future use. It should be canned or bottled while hot and tightly sealed or corked to prevent molding.

QUALITY OF THE SIRUP.

The sirup produced from beets is dark in color. This would be objectionable if the product were placed on the market, but for home use it probably would not be regarded as serious, in view of the quality of the product and the simplicity of the process. Any method of bleaching or otherwise removing the dark color would require considerable skill and some outlay of money. The desire being to produce a palatable and nutritious article of food which can be made in almost any home, the writers have aimed to avoid all technical and expensive methods. The flavor of the sirup is pleasant. It contains the pure juice of the beet root and is a wholesome and nutritious food, which to a certain degree should be helpful in reducing the sugar bill.

USES OF BEET SIRUP.

Beet sirup may be used for all purposes for which other sirups or molasses would be employed, especially for table use; for example, on buckwheat cakes, in making dark-colored cake, or in preparing certain kinds of homemade candy. If the evaporation is carried far enough and the sirup is allowed to stand, a dark sugar will settle out. This sugar will be found very satisfactory for home use in cases where refined sugar is not necessary, such as in making pies or dark-colored cake.

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HOW TO SELECT FOODS

III. FOODS RICH IN PROTEIN

CAROLINE L. HUNT and HELEN W. ATWATER
Scientific Assistants, Office of Home Economics

FARMERS' BULLETIN 824

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the States Relation Service
A. C. TRUE, Director

Washington, D. C. July, 1917

Additional copies of this bulletin may be obtained free from the
Division of Publications, U. S. Department of Agriculture

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THIS series of bulletins on the selection of food discusses briefly those principles of nutrition which the houskeeper should understand in order to plan meals wisely and economically. They do not attempt to give definite suggestions for obtaining foods at low cost nor recommend any special foods or combinations of foods.

This bulletin deals with food materials which are rich in protein and tells why the body needs this nutrient and how much is supplied by different foods.

Since the protein foods include many of the more expensive foods in common use, and since an adequate supply of protein is essential to the growth and upkeep of the body, it is especially important for the housekeeper to know how much her family needs and to be able to choose the materials which, in her particular circumstances, will best provide the proper kind and amount.

HOW TO SELECT FOODS[1]

III. FOODS RICH IN PROTEIN.

CONTENTS.

	Page.		Page.
Importance of protein and foods which supply it	1	Different kinds of protein	9
How much protein is needed	4	Cost of protein in different kinds of food	10
How much protein different foods supply	6	Use of protein-rich foods in cookery	12
		Points to remember about protein foods	18

IMPORTANCE OF PROTEIN AND FOODS WHICH SUPPLY IT.

Every farmer knows that nitrogen is one of the chemical elements which neither his crops nor his stock can do without. He knows also that it costs more than any other necessary element. The same is true of nitrogen in human food. It is absolutely necessary for the building and repairing of body tissues and can be obtained by the body only from the food substance or nutrient known as protein.

A larger proportion of protein is found in eggs, meats, fish, milk, cheese, and the dried seeds of the legumes (peas, beans, cowpeas, soy beans, peanuts, etc.) than in most other materials, and these usually are spoken of as foods rich in protein, or the protein group of foods. Except for the dried legumes, these protein-rich foods are all of animal origin and are mostly among the more expensive food materials. Some of the cereals, especially wheat and oats, and some of the nuts are also fairly rich in protein, while smaller amounts are found in the other cereals and minute quantities in vegetables and fruits.

Milk is included among the protein-rich foods, although seven-eighths of it is water, and both fat and milk sugar are more abundant in it than protein. The particular form of protein it supplies is especially valuable.

Milk is the best source of protein for little children and should be the chief item in their diet (see p. 9). Besides furnishing protein, it provides them with some of the mineral matter necessary to build tissue and with certain other substances which, in tiny quantities at least, are indispensable for healthy growth and development. Like any kind of protein, it can also be used by the body as fuel to provide energy for the work of the muscles.

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[1] Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.

It does not make so much difference from which materials older persons get their supply of protein, though a variety of kinds is usually considered desirable. Not all of it ordinarily comes from the protein-rich foods, for wheat and other cereals contribute much protein to the diet. In fact, it is possible to plan perfectly wholesome and appetizing diets in which about half of the necessary protein is furnished by bread and other cereal foods. Rations so planned have been discussed in other bulletins of this series.[1]

The following lists may help to show about how much protein there is in some of the common food materials and how they compare with one another in this respect. The second list is illustrated on the title page of this bulletin.

There is about ¼ ounce of protein in—	There is about 1 ounce of protein in—
1 glass milk.	1 quart milk.
1 egg.	4 eggs.
1½ to 2 ounces medium fat meat.	6 to 8 ounces medium fat meat.
Whole-milk cheese (1 ounce or 1⅛ cubic inches).	4 ounces whole-milk cheese.
1½ ounces dried navy beans.	6 ounces dried navy beans.
3 medium-sized slices bread, either white or whole-wheat (3 ounces).	1 small loaf bread, either white or whole-wheat (12 ounces).

HOW MUCH PROTEIN IS NEEDED.

It is not necessary for a healthy person to measure his food as carefully as a doctor measures the medicines or even the food which he prescribes for an invalid. If the body is in good condition it adapts itself to the ordinary variations in its food supply; when there is a little too much it can store or dispose of what it does not need at once, and when there is not enough it can draw for a time on its own substance to make good the lack. The danger comes when, day in and day out, the body gets too much or too little food, or when the kinds provided are not the most suitable. There is no need of measuring exactly how much protein is obtained with every meal, but if the diet as a whole is to be healthful and economical, the person who plans it ought to know in a general way how much protein and other nutrients are needed and how much is contained in the different food materials, and then choose accordingly.

In an earlier bulletin of this series[2] the diet as a whole was considered and a simple way of planning wholesome, economical, and attractive meals was suggested. The housekeeper was advised to think of the common food materials as grouped under five heads and to make sure that the diet every day included something from each of the five groups.

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[1] U. S. Dept. Agr., Farmers' Bul. 808 (1917). How to Select Foods.—I, What the Body Needs. U. S. Dept. Agr., Farmers' Bul. 817 (1917). How to Select Foods.—II, Cereal Foods.

[2] U. S. Dept. Agr. Farmers' Bul. 808 (1917). How to Select Foods.—I. What the Body Needs.

The five groups are as follows:

(1) Fruits and vegetables. Without these there is danger that the diet may be lacking in mineral matter and other substances needed in the making of tissues and for keeping the body in health.

(2) Milk, cheese, eggs, meat, fish, and dried legumes (peas, beans, etc.). Without these there is danger that the diet may be lacking in protein, an indispensable tissue builder.

(3) Cereals (wheat, oats, rye, corn, barley, and rice) and their products. Without these the diet would contain practically no starch, the cheapest kind of body fuel.

(4) Sugar, molasses, sirups, honey, and other sweets. Without these the diet would be lacking in sugar, valued as body fuel and for its flavor.

(5) Fats (butter, lard, meat fat, and olive, peanut, cottonseed, and other fats and oils). Without these the diet might be lacking in fat, which has a high value as body fuel and gives to food an agreeable quality commonly called "richness."

This bulletin deals chiefly with the second or protein group.

According to the standard commonly used in this country as a practical guide in planning meals[1] about 3½ ounces of protein a day is a reasonable quantity for a young or middle-aged man of average size, weighing about 150 pounds and doing a moderate amount of muscular work—like that of a carpenter. It is believed that it is wise to obtain this protein from a variety of food materials (see p. 9).

Half of this protein (about 1¾ ounces) he might get from a pound loaf of bread and 4 ounces of oatmeal porridge or other cooked cereal used as a breakfast food. The other 1¾ ounces probably would be supplied chiefly by one or more of the following: Meats, fish, eggs, milk, cheese, and dried legumes. It might be obtained from an egg at breakfast, one-half pound of pork chops or mutton chops (weighed with bones and trimmings) at dinner, and three-quarters cup (6 ounces) of baked beans or cowpeas at lunch or supper.

As before stated, this is about the amount of protein needed by a man of average size and weight. A larger person would have more body tissue to keep in repair, so would require more protein, while a smaller person would require less. Women, in general, are smaller and weigh less than men, and a woman of average size, weighing from 120 to 130 pounds, is commonly said to need about four-fifths as much protein as a 150-pound man. Growing children need more protein in proportion to their size than adults, because they must increase the amount of their body tissue as well as keep it in repair.

The more active a person is, the more force or energy he will expend and the more food must be provided for this purpose. This use of food as body energy or fuel has been discussed in other bulletins of this series, and rations have been suggested which provide the total food needed for a man doing moderate muscular work and for a family.[1] When a person does more muscular work and therefore needs more food, it is usually wise to increase the use of materials rich in fat, starch, or sugar rather than of those rich in protein, not only because the former are often cheaper, but because such a diet usually pleases the taste quite as well. It has been found that when a diet consisting of the common food materials combined in the usual way provides enough energy, it is almost certain to provide enough protein, too.

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[1] U. S. Dept. Agr., Farmers' Bul. 142 (1917), p. 33.

If the food provides more protein than the body needs for tissue building, the excess may be used by the body as fuel. Unless this excess is unusually great it will not prove harmful ordinarily.

Applying these points to the quantity of protein needed daily, it is found that, compared with the 3½ ounces of protein needed by a 150-pound man, a woman weighing 120 to 130 pounds and doing moderate muscular work would need about 2⅘ ounces. If she were to use food materials similar to those in the diet described for the man, she might cut down the bread from 1 pound to three-fourths pound (or by about four slices), and could get along with three-eighths pound (6 ounces) of meat instead of half a pound. A child up to three or four years of age needs daily as much protein as would be supplied by a quart of milk or by 1½ pints of milk and one egg.

A family consisting of father, mother, and three children between 3 and 12 years of age would require about 3½ times as much as the man, or not quite three-fourths pound (12 ounces) of protein. This would be supplied by the following day's ration: Three pounds of bread and 1 pound of cooked cereal mush, three-fourths cup of fat (butter, etc.), 1¼ cups of sugar, 4 or 5 pounds of fresh fruit and fresh or root vegetables, 1 pound of meat, and 3 quarts of milk.

These amounts are intended to meet the needs of a family in which the father does about as much muscular work as that required by the carpenter's trade and the mother that required for cooking, cleaning, and general housework. If they both lead sedentary lives, the protein might safely be cut down by one-tenth or even one-eighth.[2]

HOW MUCH PROTEIN DIFFERENT FOODS SUPPLY.

Because protein is so important to the health of the body, it is not considered desirable in diets consisting of the ordinary combinations of food materials to cut down the quantity in the daily food below that just suggested. How then can the housekeeper reduce the cost of food and still provide enough of this necessary but expensive material? The best way is to learn how much protein is provided by different kinds of food and then choose the kinds which will furnish what the family needs for the lowest cost and with the least waste. This task will be easier if the housewife will group in her mind the foods which are rich in protein and then consider ways of substituting less expensive for more expensive ones.

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[1] U. S. Dept. Agr., Farmers' Bul. 808 (1917). How to Select Foods.—I. What the Body Needs. U. S. Dept. Agr., Farmers' Bul. 817 (1917). How to Select Foods.—II. Cereal Foods.

[2] U. S. Dept. Agr., Farmers' Bul. 142 (1916). Principles of Nutrition and Nutritive Values of Food.

The lists given below include some of the more common foods in which protein is abundant and show in a general way the amounts and proportion of protein in the different kinds as they are purchased; that is, including refuse, such as bones and gristle, egg shells, etc.

Approximate amounts of protein in common food materials.

Fresh meats:
  Beef contains from 2 to 3 ounces of protein per pound.
  Veal contains from 2 to 3 ounces of protein per pound.
  Mutton contains from 2 to 2¼ ounces of protein per pound.
  Lamb contains about 2¼ ounces of protein per pound.
  Pork contains about 2 ounces of protein per pound.
  Poultry—chicken, duck, goose, turkey, etc.—contains from 2 to 2¼ ounces of protein per pound.
  Game—squirrel, rabbit, wild birds, etc.—contains from 2 to 2¼ ounces of protein per pound.
Prepared meats:
  Corned beef contains 2¼ ounces of protein per pound.
  Dried beef contains 4 ounces of protein per pound.
  Pork sausage contains 2 ounces of protein per pound.
  Canned chicken contains 4 ounces of protein per pound.
Fresh fish—cod, haddock, halibut, mackerel, perch, salmon, shad, etc.—contains from 1½ to 2½ ounces of protein per pound.
Dried fish contains from 2½ to 3 ounces of protein per pound.
Eggs contain 2 ounces of protein per pound.
Dairy products:
  Whole milk contains about 1 ounce of protein per quart.
  Skim milk contains about 1 ounce of protein per quart.
  Buttermilk contains about 1 ounce of protein per quart.
  Condensed milk contains about 1 ounce of protein per 12-ounce can.
  Whole-milk cheese contains about 4 ounces of protein per pound.
  Cottage cheese contains about 3 ounces of protein per pound.
Dried legumes:
  Beans contain 3 ounces of protein per pound.
  Cowpeas contain 3 ounces of protein per pound.
  Peas contain 4 ounces of protein per pound.
  Peanuts contain 3 ounces of protein per pound.
Nuts:
  Almonds contain nearly 2 ounces of protein per pound.
  Walnuts contain a little over 1 ounce of protein per pound.
Cereal foods:
  Wheat flour contains 2 ounces of protein per pound.
  Corn meal contains 1¼ ounces of protein per pound.
  Oat meal contains 2⅔ ounces of protein per pound.
  Bread contains 1½ ounces of protein per pound.

For some purposes it may be more convenient to have the protein present in different food materials expressed in fractions or percentages of the whole. This is done in the following summary:

Approximate proportions of protein in common food materials.

Fresh meats:
    Beef, one-eighth to one-fifth, or 12 to 20 per cent protein.
    Veal, one-eighth to one-fifth, or 12 to 20 per cent protein.
    Mutton, one-eighth to one-seventh, or 12 to 14 per cent protein.
    Lamb, one-seventh, or 14 per cent protein.
    Pork, one-eighth, or 12 per cent protein.
    Poultry—chicken, duck, goose, turkey, etc.—one-eighth to one-seventh, or 12 to 14 per cent protein.
    Game—squirrel, rabbit, wild birds, etc.—one-eighth to one-seventh, or 12 to 14 per cent protein.
Prepared meats:
    Corned beef, one-seventh, or 14 per cent protein.
    Dried beef, one-fourth, or 25 per cent protein.
    Pork sausage, one-eighth, or 12 per cent protein.
    Canned chicken, one-fourth, or 25 per cent protein.
Fresh fish—cod, haddock, halibut, mackerel, perch, salmon, shad, etc.—one-tenth to one-seventh, or 10 to 14 per cent protein.
Dried fish, one-sixth to one-fifth, or 16 to 20 per cent protein.
Eggs, one-eighth, or 12 per cent protein.
Dairy products:
    Whole milk, one-thirtieth, or 3 per cent protein.
    Skim milk, one-thirtieth, or 3 per cent protein.
    Buttermilk, one-thirtieth, or 3 per cent protein.
    Condensed milk, one-eighth, or 12 per cent protein.
    Whole-milk cheese, one-fourth, or 25 per cent protein.
    Cottage cheese, one-fifth, or 20 per cent protein.
Dried legumes:
    Beans, one-fifth, or 20 per cent protein.
    Cowpeas, one-fifth, or 20 per cent protein.
    Peas, one-fourth, or 25 per cent protein.
    Peanuts, one-fifth, or 20 per cent protein.
Nuts:
    Almonds, one-ninth, or 11 per cent protein.
    Walnuts, one-fourteenth, or 7 per cent protein.
Cereal foods:
    Wheat flour, one-eighth, or 12 per cent protein.
    Corn meal, one-fourteenth, or 7 per cent protein.
    Oat meal, one-sixth, or 16 per cent protein.
    Bread, one-eleventh, or 9 per cent protein.

In considering the amount of protein supplied by certain foods, one must make a distinction between the cooked and the uncooked state. Dried legumes and cereals, for example, usually take up considerable water during cooking, and thus become more bulky and dilute. A pound of baked beans supplies the body with about one-third as much protein as a pound of raw beans. Oatmeal takes up so much water in cooking that a pound of boiled oatmeal has only about one-eighth the food value of a pound of raw. A pound of raw beans or oatmeal would have practically the same total food value after cooking as before, but their weight would be greater. In the same way, a cupful of raw beans or oatmeal would make several cupfuls when cooked.

When eggs are beaten, as in making omelets and meringues, air is forced into them and they become more bulky. In this way a given number of eggs can often be made to serve more persons than if they are prepared without beating; but each person gets less egg. If meat is made into stew, it goes farther, because the water adds to the bulk of the dish; but the finished dish has much lower protein and fuel value than the original meat. When meat is cooked without water, as in roasting, broiling, or frying, there is not much change in its composition.

A housekeeper in choosing foods at market rightly compares them in their raw state; but when she is considering them as they are actually served at meals, she must remember these differences in cooking. They should also be considered in choosing dishes at restaurants. Changes in cooking cereals are discussed in another bulletin of this series.[1]

DIFFERENT KINDS OF PROTEIN.

Protein is abundant in so many animal foods, because the other animals, as well as human beings, need it for building and maintaining their bodies. Plants also need nitrogen for building their structure, especially the seed from which new plants are to develop. The plants vary in this respect, protein being especially abundant in the ripe seeds of the pulse or bean family (also called the legumes), the cereals, and some of the nuts.

Because the protein serves a different purpose in the different plants and animals or in different parts of the same one, protein from one source is not always quite the same in character as that from another. Moreover, because animals resemble human beings more than plants do, protein of animal origin is in some ways (though not in every way) specially well adapted to human needs. This is particularly true in the case of milk and eggs, which are provided by nature for the nourishment of young animals, and which often are exceptionally adapted to the needs of children and invalids.

Protein as it occurs in vegetable foods is not usually as thoroughly digested and utilized in the human body as that from animal foods. From this it must not be supposed that vegetable protein is lacking in value, or harmful, or likely to cause distress to the eater. On the contrary, the fact that in vegetable foods the protein is combined with indigestible cellulose gives them bulk and prevents the food from becoming too concentrated during digestion, thus perhaps compensating for the lower digestibility of the protein. However, in considering their value as sources of body protein, one must remember that more than one-eighth of the protein found in the cereals and one-sixth of that in the legumes is not ordinarily utilized by the body and plan the meals accordingly.

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[1] U. S. Dept. Agr., Farmers' Bul. 817 (1917). How to Select Foods—II. Cereal Foods.

It is only within a few years that scientists have begun to realize how different kinds of protein vary in food value, and their knowledge of the matter is still very incomplete. In time they may be able to say exactly how much of each kind should go into the perfect diet and by so doing reduce somewhat the total amount of protein now thought necessary. At present such careful reckoning is not feasible; at least, for the ordinary person, and the safest course seems to be to choose a diet which a variety of animal and vegetable food materials shall provide the amount of protein mentioned on page 5.

COST OF PROTEIN IN DIFFERENT KINDS OF FOOD.

Prices vary so much with place and season that definite statements about the cost of different materials are out of the question. What one can do, however, is to reckon how much one may pay at current prices for one material, say milk, eggs, or cheese, in order to obtain protein as cheaply as from another material, say meat at 25 cents a pound.

A pound of meat, medium fat and with an average amount of refuse (bones, trimmings, etc.) supplies about 2 ounces of protein. Eight eggs yield practically the same amount. If eggs cost 36 cents a dozen, 24 cents' worth will furnish about as much protein as a pound of meat at 25 cents. In other words, eggs at 36 cents a dozen are a little cheaper as sources of protein than meat at 25 cents a pound. If the meat costs 30 cents a pound, one may buy eggs at 45 cents a dozen and still get as much protein for one's money. If meat costs 35 cents and eggs 60 cents, however, the protein from the eggs is a little more expensive than that from the meat.

In the same way it may be reckoned that milk, which contains about 1 ounce of protein to the quart, might cost 12½ cents a quart and still provide protein as cheaply as meat at 25 cents a pound.

A pound of whole-milk cheese contains about 4 ounces of protein or a little more than twice as much as most meat, so that it might cost twice as much as meat and still be as economical a source of protein. If, as is often the case, it costs less than meat, its protein is, of course, more than twice as cheap.

In the table following comparisons like those just given are shown in a slightly different way.

Protein and energy purchasable for 25 cents, from foods at certain assumed prices per pound.

Material and price.	Protein and energy obtained for 25 cents.	
	Ounces of protein.	Calories of energy.
Milk at—		
8 cents a quart	3¼	1,970
10 cents a quart	2½	1,575
12 cents a quart	2¼	1,315
Skim milk at 5 cents a quart	5¼	1,650
Full-cream cheese at—		
15 cents a pound	7½	3,325
25 cents a pound	4½	1,995
35 cents a pound	3¼	1,425
Cottage cheese, at 15 cents a pound	5½	835
Eggs at—		
25 cents a dozen	2¾	895
35 cents a dozen	2	640
60 cents a dozen	1¼	370
Beef (sides, medium fat), at—		
25 cents a pound	2¼	1,005
30 cents a pound	2	840
35 cents a pound	1¾	720
Cod, fresh, at—		
15 cents a pound	3	350
20 cents a pound	2	265
Salmon, fresh, at—		
20 cents a pound	2¾	725
35 cents a pound	1½	415
Salmon, canned, at—		
20 cents a pound	3¾	850
35 cents a pound	2¼	485
Cod, salt, at—		
10 cents a pound	7½	900
15 cents a pound	5	600
Herring, smoked, at—		
12 cents a pound	6½	1,520
16 cents a pound	5	1,140
Wheat flour, at—		
5 cents a pound	7¾	8,050
7 cents a pound	5½	5,750
Corn meal, at—		
3 cents a pound	10½	13,460
5 cents a pound	6¼	8,075
Oatmeal, at—		
5 cents a pound	11	9,050
8 cents a pound	7	5,655
White bread, at—		
5 cents a pound	6¼	5,925
5 cents for 12-ounce loaf (about 7 cents a pound)	4½	4,445
Rice, at—		
8 cents a pound	3½	4,970
12 cents a pound	2¼	3,315
Dried beans, at—		
8 cents a pound	8¾	4,890
15 cents a pound	4½	2,610
Dried peas, at—		
10 cents a pound	7¾	4,025
20 cents a pound	4	2,015
Peanuts, at—		
6 cents a quart	7	4,635
10 cents a quart	4	2,785
Almonds, at—		
18 cents a pound	2¼	2,245
25 cents a pound	1¾	1,615

The figures in the first column of this table tell about how much protein one would obtain in 25 cents' worth of some of the common protein foods. Two or more prices are given for each material. To show how the list may be used, let it be supposed that a housekeeper wishes to know which is cheaper as a source of protein, eggs at 35 cents a dozen or cheese at 25 cents a pound. She looks at the figures opposite these two items and finds that cheese is decidedly cheaper, yielding 4 ounces where eggs yield only 2¼ ounces.

The figures in this table take account of the fact that some kinds of protein are more completely utilized by the body than others. They represent the amount of available protein rather than the total amount found in the food as purchased. The difference between total and available protein is greatest in the legumes and least in the animal foods (see pp. 9 and 10).

The second column of figures refers not to the protein but to the amount of body fuel or energy that the different materials would furnish. This bulletin is not so much concerned with the question of energy as with that of protein (see p. 4). Still, it should not be forgotten that foods must be considered from the standpoint of the energy as well as the building and regulating materials they furnish, and even in choosing among the protein-rich foods it is important to know how they compare in both respects. Two quarts of milk, eight eggs, and a pound of medium-fat meat yield 2 ounces of protein each, but the meat contains so much more fat that it yields more than three times as much body fuel or energy as the milk and nearly twice as much as the eggs. By comparing the figures given for one material with those for another one can quickly see which furnishes fuel more economically, even if one does not understand exactly how the measurements are made.[1] Thus, if the figure opposite milk at 8 cents a quart is 1,970 and that opposite bread at 7 cents a pound is 4,445, it is easy to see that, as a source of body fuel. the milk is more than twice as dear as the bread.

USE OF PROTEIN-RICH FOODS IN COOKERY.

Protein usually is introduced into meals in two ways: First, by means of dishes made up principally of a protein-rich food such as meat, milk, or eggs, and, second, by dishes or combinations in which a small proportion of protein-rich food is used with materials from other food groups, as when milk and eggs are used in the preparation of soups, vegetables,cakes, etc.; when cheese is served with pie or other dessert; or when nuts are served as dessert, are used in making bread, cakes, or puddings, or are added to salads. Recipes for both types of dishes are given below. The first four furnish enough protein to be relied on as the main supply at an ordinary meal. The others will be found to contain more protein than many persons would suppose. The amount of protein contained in each dish is stated, so that the housekeeper may form an idea of how much of the day's supply (see p. 5) may be obtained from it.

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[1] U. S. Dept. Agr., Farmers' Bul. 142 (1915). Principles of Nutrition and Nutritive Value of Food.

Beef and Bean Stew.

(This dish contains 3 or 4 ounces of protein.)

1 pound beef, lower round.
1 cup red kidney beans.
1 onion.
1 cup canned tomatoes, or 2 or 3 fresh tomatoes.
2 ounces salt pork.

Wash the beans and soak them overnight. Cut the pork into small pieces and try out the fat. Cut the beef into small pieces and brown it in the pork fat, then add the vegetables with water enough to cover. Cook just below the boiling point for about three hours.

This dish serves about 8 persons.

Baked Pork and Beans, or Cowpeas.

(This dish contains 6 or 7 ounces of available protein.)

1 quart navy beans.
¾ pound salt pork.
2 teaspoons salt.
¼ cup molasses or brown sugar.

Wash the beans (either navy, lima, or other beans, or cowpeas); soak them in cold water overnight or an equal length of time by day. Pour off the water and boil until they are soft. Again drain and place in a bean pot. Pour boiling water over the salt pork and scrape the rind until it is white. Cut slashes through the rind one-half inch apart. Bury the pork in the beans, leaving the rind exposed. Add the salt and the molasses or sugar, or a mixture of the two. Cover the beans with hot water and bake six or eight hours in a covered dish. Remove the cover and allow the beans to brown on top.

This dish serves 10 to 12 persons.

Baked Soy or Togo Beans.

(This dish provides about 6 ounces of available protein.)

Soy beans, known in the retail market as togo beans, resemble navy beans in some ways. They contain, however, a considerable amount of fat. For this reason neither pork nor other fat is used in cooking them unless it is wanted for flavor. They are considerably richer in protein also.

Wash and pick over 1 quart of soy beans. Cover with boiling water, boil for 10 minutes, and soak overnight in the same water. In the morning pour off and save the water. Pour cold water over the beans and rub them between the hands to remove the skins, which will float off in the water. Removing the skins in this way takes only two or three minutes and greatly improves the quality of the dish. If a few skins are left on, they will do no harm, unless the dish is being prepared for a person of poor digestion. Drain the beans, pour over them the water in which they were soaked, and cook until tender at a temperature just below the boiling point. Pour off the water, put the beans into a bean pot, cover with cold water, add 1½ tablespoonfuls of salt, and bake four or five hours in a covered dish. Remove the cover and bake one hour more.

This dish serves 10 to 12 persons.

Salt Codfish Chowder.

(This dish provides about 3 ounces of protein.)

½ pound salt codfish.
4 cups potatoes, cut into small pieces.
2 ounces salt pork.
1 small onion, chopped.
4 cups skim milk.
4 ounces crackers.

Pick over and shred the codfish, holding it under lukewarm water. Let it soak while the other ingredients of the dish are being prepared. Cut the pork into small pieces and fry it with the onion until both are a delicate brown, add the potatoes, cover with water, and cook until the potatoes are soft. Add the milk and codfish and reheat. Salt, if necessary. It is well to allow the crackers to soak in the milk while the potatoes are being cooked, then remove them, and finally add to the chowder just before serving.

This dish serves about 6 persons.

SCALLOPED FISH.

(The following dish, made from grayfish recommended by the Bureau of Fisheries as comparatively cheap, contains about 3 ounces of protein.)

1 can (14 to 16 ounces) grayfish, from which liquid has been drained.
2 level tablespoons cooking fat.
3 level tablespoons flour.
1 teaspoon lemon juice or vinegar, or ½ tablespoon finely chopped capers or sour pickle.
1 cup liquid (water, milk, tomato juice, or canned tomato soup).
Few drops onion juice.
Few grains cayenne pepper.

Melt the butter, add the flour, and cook for one minute; then add the liquid and boil until the mixture thickens. Add the seasoning. Do not make the mistake of oversalting this sauce. Into a baking dish put alternate layers of fish and sauce, cover with buttered crumbs, and bake.

If tomato juice or tomato soup is used in place of water, omit the lemon juice. If economy is an object, use vinegar in place of lemon juice. Either may be used with milk, provided it is not added until the sauce has become thick.

Any other canned fish or "left-overs" of cooked fresh fish may be used in place of the grayfish. If salmon or other fat fish is substituted, not so much cooking fat will be needed as with lean kinds, such as grayfish, cod, and so on.

This dish serves 4 to 6 persons.

Most people realize that they are introducing considerable protein into their meals by the use of meat and such dishes as those for which recipes are given above. Few realize, however, how large an amount is introduced in small quantities by means of soup or dessert.

This is shown by figures 1 and 2, representing meals which furnish equal amounts of protein. That in figure 1 consists of clear soup, bread and butter, two pork chops, potato and tomato, pineapple, and frosted cakes of the so-called butter-cake type. The meal in figure 2 includes the same quantities of bread and butter and of vegetables. Only one chop is used, but the protein (and also the energy) thus lost is made good by using a milk soup in place of the clear soup, and serving baked custard and sponge cake instead of fruit and frosted cake for dessert.

Other ways of introducing the same quantity of protein by material of different kinds can easily be found.

For example, in a breakfast of 2 eggs and 3 ounces of toast (yielding as much protein as 2 ounces of uncooked cereal), with fruit, butter, and sugar, the eggs would provide the greater part of the protein. If for the two eggs there were substituted 2 cups, or 1 pint, of milk, the meal would provide just as much protein. The milk might be served as a beverage or on a cereal breakfast food; or be used in making such dishes as cereal mush, muffins, corn bread, or milk gravy. In this case protein equal to that in two eggs might be distributed through several dishes.

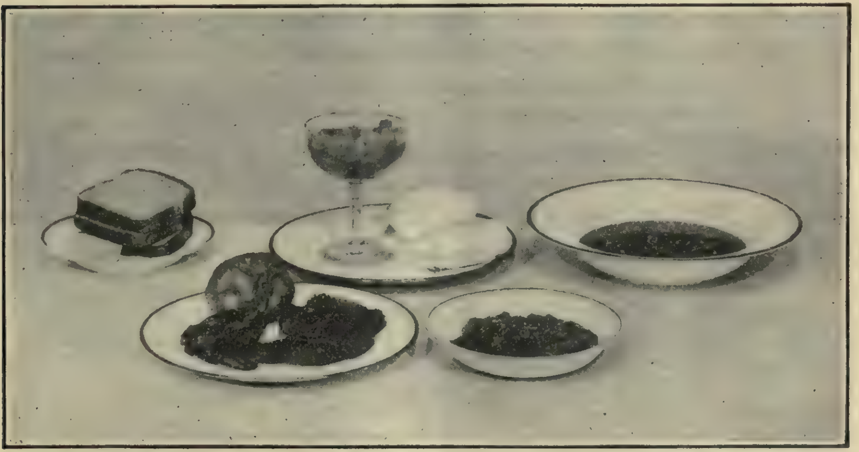
FIG. 1.—Meal in which protein equal in amount to that in figure 2 is supplied mainly by two chops.

In a lunch consisting of 4 ounces of fish, with bread and butter, a salad of fresh vegetables, and boiled rice and honey for dessert, the greater part of the protein would be supplied by the fish. If 2 ounces of ordinary cheese or one-fourth cup of cottage cheese were substituted for the fish, and a cup of custard (4 ounces) were substituted for the fruit, the lunch would supply just as much protein.

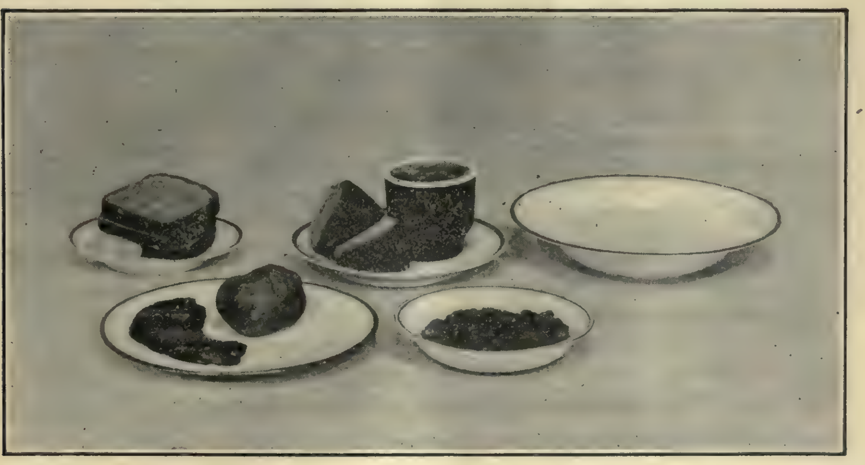
FIG. 2.—Meal containing the same amount of protein as that in figure 1, but partly from one chop and partly from eggs and milk used in soup, custard, and sponge cake.

In a dinner consisting of 4 ounces of roast beef, with bread and butter, vegetables cooked without the addition of milk or other protein-rich food, and a fruit pudding for dessert, the greater part of the protein would be supplied by the meat. If a soup made from 1 ounce of dried beans were served, one-half cup of milk used in the preparation of the vegetables, and 1 ounce of shelled nuts used for dessert in place of the pudding, it would be possible to reduce the meat to 2 ounces without lessening the amount of protein in the meal.

The following recipes are for dishes of the second type described on page 12, i. e., those in which a smaller amount of protein-rich food is combined with a larger amount of material from the other food groups. The amount of protein each contains is stated in each case.

Sponge Cake.

(Sponge cake made according to the following recipe contains about 1¾ ounces of protein. It is an expensive cake except where eggs are cheap, and should not be used in a diet otherwise well supplied with protein.)

Yolks 6 eggs.
1 cup sugar.
1 tablespoon lemon juice.
1 cup flour.
Flavoring.
Grated rind ½ lemon.
Whites 6 eggs.
¼ teaspoon salt.

Beat the yolks thoroughly, add the sugar, and beat until smooth. Add the salt to the whites of the eggs and beat them until stiff. Carefully mix yolks, whites, and sifted flour, handling so as not to drive out the air. Bake one hour in a slow oven.

This cake may be flavored with a tablespoonful of lemon juice and the rind of half a lemon, or with any common flavoring extract. If the eggs are perfectly fresh, however, it needs no flavoring, and this expense can be saved.

Eight medium-sized slices can be cut from such a cake.

Baked Custard.

(The following custard contains 2½ ounces of protein.)

4 cups scalded skim milk.
6 eggs.
½ cup sugar.
¼ teaspoon salt.
A little grated nutmeg or powdered cinnamon.

Beat the eggs slightly; add the sugar, salt, flavoring, and hot milk. Pour into a buttered mold. Set in a pan of hot water and bake until firm.

This custard serves 6 to 8 persons.

Dried Bean Purée.

(This dish provides about 2 ounces of protein.)

2 cups dried beans.
2 quarts water.
1 onion.
½ tablespoon salt.
1 ounce, or 2 cubic inches, salt pork.

Soak the beans overnight, and in the morning drain and cover with cold water. Add the other ingredients and cook until the beans are tender. This soup may be eaten strained or unstrained. It may be boiled down until thick, or it may be thickened with a little flour.

A similar soup may be made from any kind of dried legumes, including soy beans, dried peas, lentils, or cowpeas.

Tomato juice may be added for flavoring, or the tops and roots of celery. Lemon juice improves the flavor.

This dish serves 6 to 8 persons.

SCALLOPED CORN.

(This dish furnishes a little over 1 ounce of protein.)

2 cups chopped corn.
2 eggs.
1 teaspoon salt.
1 pint scalded skim milk.

Beat the eggs slightly, add the other ingredients, place in a buttered baking dish, and bake in a slow oven until firm.

This dish serves 4 to 6 persons.

Recipes for potatoes, cabbage, and cauliflower prepared with cheese have been published in an earlier bulletin.[1]

As practical help in planning meals, it may be recalled that one hard-boiled egg used as a garnish on spinach or in a sauce on potato or other vegetable adds one-fourth ounce of protein to the meal, and that one-half ounce of almonds, which would be 10 or 12 nuts, an average allowance for one person as dessert, supplies about one-eighth ounce of protein. If raisins are served with the nuts, they add not only sugar and mineral matters, but also a very small amount of protein.

In families where eggs, milk, and other protein-rich foods are used freely in cookery, it is often easier to judge the amount of protein provided by the week than by the meal or the day.

In another bulletin[2] of this series the statement was made that a family consisting of father, mother, and three young children would get enough protein from a daily ration containing as much protein as is found in 2 quarts of milk and 1½ pounds of other protein-rich foods (meat, eggs, cheese, etc.) or 3 quarts of milk and 1 pound of the other protein-rich foods, providing cereal foods were freely used in addition. Such a ration would require a weekly allowance of 14 quarts of milk and 10½ pounds of meat, fish, poultry, eggs, cheese, etc., or of 21 quarts of milk and 7 pounds of meat, fish, poultry, eggs, cheese, etc. Those who use milk and eggs freely in cookery should remember that every extra quart of milk used during the week, either in cooking or otherwise, makes it possible to reduce the allowance of meat, etc., by one-half pound and every extra dozen of eggs used, either in cooking or otherwise, makes it possible to reduce this weekly allowance of meat by at least 1½ pounds.

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[1] U. S. Dept. Agr., Farmers' Bul. 487 (1915), p. 33. Cheese and Its Economical Uses in the Diet.

[2] U. S. Dept. Agr., Farmers' Bul. 808 (1917). How to Select Foods.—I. What the Body Needs.

POINTS TO REMEMBER ABOUT PROTEIN FOODS.

Protein is necessary in the diet, because it supplies nitrogen needed for building and renewing body tissues.

The foods usually classed as rich in protein are: Milk and cheese; eggs; meat, poultry, and fish; dried legumes, such as peas, beans, cowpeas, soy beans, and peanuts; and almonds and some other nuts. Wheat, oats, and some other cereals also furnish considerable amounts of protein.

Milk is the best source of protein for children.

There is about one-fourth ounce of protein in each of the following: One glass of milk, one egg, 1½ to 2 ounces of meat, 1 ounce of cheese, and 13 ounces of bread.

The proportion of protein in cooked and uncooked foods often varies because they take up water during cooking and thus become more bulky and more dilute. A given weight of baked beans contains only about one-third as much protein as the same weight of raw ones, and boiled cereals from one-eighth to one-third, according to the amount of water they absorb.

A man at moderate muscular work is believed to need about 3½ ounces of protein a day, and a family consisting of father, mother, and three small children about 12 ounces a day.

A diet which is made up of the usual combination of food materials and which furnishes the body with enough energy usually furnishes enough protein. Nevertheless, because the protein-rich foods are among the most expensive, and because a proper variety of them is necessary for health, they must be considered very carefully in planning an economical diet.

It is possible to plan an attractive and wholesome diet in which one-half of the necessary protein is supplied by bread and other cereal foods which are relatively cheap.

The more milk, eggs, and other protein-rich foods are combined with other foods in cooking, the less protein-rich foods are needed for use as separate dishes.

Skim milk is not a substitute for whole milk as a food for little children, but it can be so used as a source of protein in the diet of adults. A quart in cooking or to drink will add as much wholesome protein to the general diet as a quart of whole milk. Providing they are clean and wholesome, sour skim milk and buttermilk may be used instead of sweet.

Real economy in the use of protein foods lies not in leaving them out of the diet, but in choosing and combining kinds which will supply the total amount needed as cheaply as circumstances permit.

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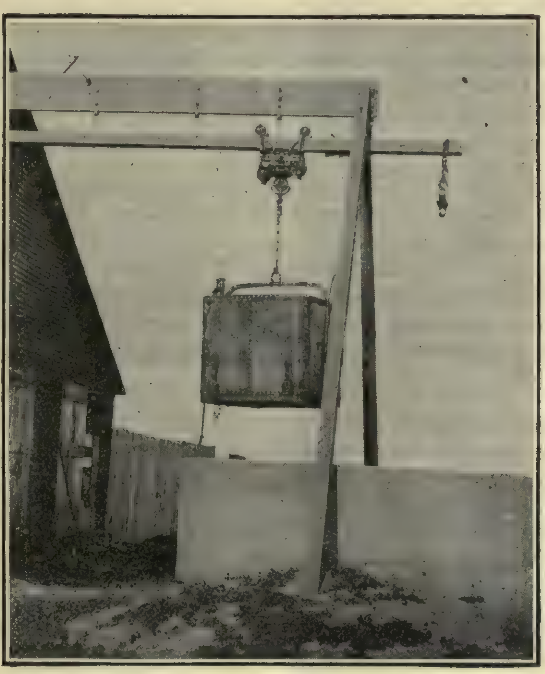
PIT SILOS

T. PRYSE METCALFE and GEORGE A. SCOTT
Animal Husbandry Division



FARMERS' BULLETIN 825

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

Washington, D. C. June, 1917

Additional copies of this bulletin may be obtained free from the
Division of Publications, U. S. Department of Agriculture

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PIT SILOS have been constructed in rapidly increasing numbers in the Great Plains region during the past few years. Their growing use has resulted from the unsatisfactory service given by silos of wood under the prevailing climatic conditions, together with the scarcity of materials necessary for constructing masonry silos and the high cost involved in getting these materials on the ground.

Pit silos can be constructed by farm labor, and a comparatively small outlay of cash is necessary. If well made they are permanent and safe, and the cost of repair is practically negligible. These underground silos should be constructed only in soils that are firm and free from rocks, sand strata, and seeps, and where the water table is always below the bottom of the floor after they are dug.

Directions are given in this bulletin for constructing pit silos, indicating the proper size and best location. The practices which have proved most satisfactory are described so that a pit silo may be made without unnecessary mistakes which would cause undue waste of time and material.

While the feeding of silage can usually be done more easily and more rapidly from the above-ground types of silos, the use of types of hoists described and illustrated herein has shown that this advantage is but a slight one.

The construction of pit silos is recommended only where a combination of soil and climatic conditions exists such as is found in the Great Plains region.

In the absence of these special conditions the ordinary types of silos, described in Farmers' Bulletin 589, " Homemade Silos," are recommended.

PIT SILOS.

CONTENTS.

	Page.		Page.
Adaptations and advantages of pit silos	3	Hoisting devices and feeding equipment	10
Location; character of soil required	4	Poisonous gases in pit silos	12
Size of silo	4	Points to be emphasized	13
Method of construction	5	Publications	14

ADAPTATIONS AND ADVANTAGES OF PIT SILOS.

Pit silos are becoming common in many sections of the Great Plains region, especially in the Panhandle of Texas and in similar sections of the United States. The popularity of this type of silo is due chiefly to the remoteness of many farms in these sections from railroad points, which in many cases would make the cost of a masonry silo prohibitive, and to the fact that silos of wood often weaken rapidly under the peculiar climatic conditions prevailing in the Plains region and are destroyed by wind. The cost of constructing a pit silo is small compared with the expense of building a masonry silo, when large quantities of cement, sand, gravel, or tile, etc., must be bought and hauled long distances. In addition to this, some skilled labor usually must be employed in the building of a concrete or tile silo, whereas with a small outlay of cash, his own labor and that of ordinary farm hands, usually none too busy during the late summer months, the farmer can construct a pit silo that will be a substantial asset to his farm.

Simply digging a "hole in the ground" does not provide a durable or satisfactorily pit silo. A little extra care and expense put into the construction will well repay the owner in greater safety, efficiency, and durability. Properly constructed pit silos should last indefinitely, and the upkeep is very small. They can not be blown down, and there is nothing about the silo itself to decay. They preserve silage fully as well as or better than above-ground types; a more uniform temperature throughout the year is maintained in them; and the silage is never frozen.

Another distinct advantage of pit silos over other silos lies in the ease and low cost of filling them. Only power to cut the material is

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NOTE.—This bulletin is intended for distribution in sections where building materials are scarce and high priced, especially applying to the Great Plains region.

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required, while with above-ground silos practically twice as much power must be used to cut the silage and elevate it to the top of the silo. Consequently, farmers having pit silos can more often afford to own their own cutting outfits, and can fill their silos at the proper time without waiting to hire expensive outfits and extra men. The labor required to hoist out the silage is distributed throughout the feeding season, which comes during a period when other farm work is not pressing.

LOCATION; CHARACTER OF SOIL REQUIRED.

Inasmuch as it is impracticable and even dangerous to dig a pit silo in a great many soils, the farmer should know the character of his soil before attempting to construct a silo of this type. The soil must be well drained, so that water will not stand in the bottom of the silo, and of such a nature that it will not readily cave in. Soils which contain bowlders or rocks are hardly satisfactory for pit silos, as the walls of the silo can hardly escape being materially defaced and weakened when the rocks are removed. Any firm, well-drained, and comparatively dry soil, free from seeps, rocks, and sand strata should prove satisfactory. Where pit silos have not been tried, the farmer should study the soil and the depth of the water table by observing any nearby well. If this is not possible, it would be advisable to bore a 2-inch hole as deep as the silo is to be, and in this way to learn the character of the soil. The maximum height of any ground water which may appear at any time in this test well will indicate the lowest point to which a pit silo should be dug in that place.

If possible the silo should be located near the feed lot to reduce the cost of feeding. If the feeding is to be done in a barn, a distance of 5 or 6 feet at least should be left between the edge of the pit and the barn.

SIZE OF SILO.

The diameter of the silo will be determined by the amount of silage to be fed daily, while the depth will depend chiefly upon the length of the feeding season. Hence the farmer should know approximately (1) the number of stock he intends to feed, (2) the approximate amount of silage to be fed daily, and (3) the number of days silage is to be fed. With this information before him, the proper diameter and depth, respectively, can be decided upon by consulting Tables I and II, which are here incorporated from Farmers' Bulletin 589.

TABLE I.—*Relation of size of herd to diameter of silo for winter feeding (on basis of 40 pounds of silage per cubic foot).*

Inside diameter of silo.	Quantity of silage in depth of 2 inches.	Number of animals that may be fed, allowing—			
		40 pounds per head.	30 pounds per head.	20 pounds per head.	15 pounds per head.
Feet.	*Pounds.*				
10	524	13	17	26	35
11	634	16	21	31	42
12	754	19	25	37	50
13	885	22	29	44	59
14	1,026	25	34	51	68
15	1,178	29	39	59	78
16	1,340	33	44	67	89
17	1,513	38	50	75	101
18	1,696	42	56	85	113
20	2,094	52	70	104	139

TABLE II.—*Depth of silage (after settling) for a given capacity of silo with a given diameter.*[1]

Depth of silage (after settling).	Capacity of silo having an inside diameter of—									
	10 feet.	11 feet.	12 feet.	13 feet.	14 feet.	15 feet.	16 feet.	17 feet.	18 feet.	20 feet.
Feet.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
24	34	....	....	....	....	....	....	....	....	....
26	38	46	55	....	....	....	....	....	....	....
28	42	51	61	71	83	....	....	....	....	....
30	47	56	67	79	91	105	....	....	....	....
32	....	62	74	86	100	115	131	....	....	....
34	....	....	80	94	109	126	143	161	....	....
36	....	....	87	102	119	136	155	175	196	....
38	....	....	....	110	128	147	167	189	212	261
40	....	....	....	....	138	158	180	203	228	281
42	....	....	....	....	....	170	193	213	245	302
44	....	....	....	....	....	....	207	234	262	323
46	....	....	....	....	....	....	....	250	280	345
48	....	....	....	....	....	....	....	....	....	368

[1] These figures were taken in part from King's Physics of Agriculture, p. 424.

The diameter of the silo should be such that after the silage feeding has begun, at least 2 inches should be removed from the surface daily. If less than 2 inches of silage is removed daily, the exposed silage will probably spoil, especially during warm weather. Make an allowance of 4 to 6 feet for settling of the silage, but figure in the wall above ground in the total depth of the silo. A general rule which is followed in silo construction is that the depth of the silo should not be less than twice nor more than three times the diameter. However, pit silos are seldom deeper than 36 feet.

METHOD OF CONSTRUCTION.

THE CURB.

When the location and size of the silo have been decided upon, mark off the trench for the curb with some such device as is shown in figure 1, keeping the arm of the marker level.

Dig a trench about 2 feet deep within these two outlined circles. This trench should be 6 to 8 inches across at the top. The inside wall should be kept perpendicular and smooth, and the bottom must be level. The concrete put into this trench forms the curbing at the top of the silo. This curb of concrete will serve as a foundation upon which a light wall and a cover may be built.

When the trench is dug, fill it with water to wet the ground thoroughly, and let it soak into the soil. Then put in the concrete, which is made of 1 part cement, 2 parts sand, 4 parts gravel or crushed rock, and the proper amount of water. To insure strength and durability the concrete must be reinforced. An ideal construction would result from embedding in the concrete three or four ¼-inch or ⅜-inch steel rods connected so as to form hoops, one of which should be near the bottom and the others placed approximately at equal distances apart as the concrete is put into the trench. Strong wire mesh securely connected at the ends may be used instead of steel rods.

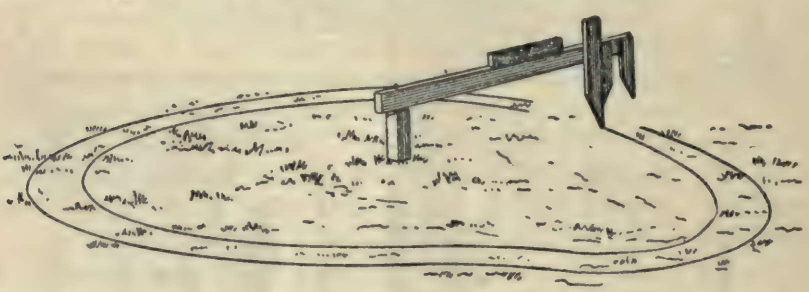

FIG. 1.—Marking off the trench for the curb. Where the ground on which the silo is to be located is not level, the markers can be lengthened by holding a longer board against either marker, as indicated in the figure, moving it up or down to keep it touching the ground, but care must be taken that the scantling is held level.

If a concrete wall is not to be constructed upon the curb, the latter should be extended about 2 feet above the ground, so that the soil can be banked up around it. Forms must be used for building the curb, or a wall, above ground. Farmers' Bulletin 461, The Use of Concrete on the Farm, and 589, Homemade Silos, give valuable information and detailed instructions concerning the mixing and handling of concrete, reinforcing concrete, the construction of forms for walls, etc. They may be had free upon request from the U. S. Department of Agriculture, Washington, D. C., and should be consulted in connection with the concrete work involved in building a pit silo, especially by those who are not thoroughly familiar with making and handling concrete.

EXCAVATING THE SOIL.

After the concrete composing the curb has set well—or in about 3 days—the digging of the pit may be started. Remove the soil, digging straight down from the inside of the curb. Be sure to keep the wall perpendicular and smooth. If the wall slopes outward, the silage will settle away, leaving an air space, and some silage will be spoiled. Should the wall slope inward, it will prevent proper settling of the silage.

Several devices have been used in helping to keep the wall straight and smooth. A simple plumb line is most often used, and a straightedge made from a 1 by 4 inch piece, used in connection with an ordinary carpenter's level, assists in keeping the wall both plumb and smooth. Figure 2 illustrates a device which has been used in the Southwest.

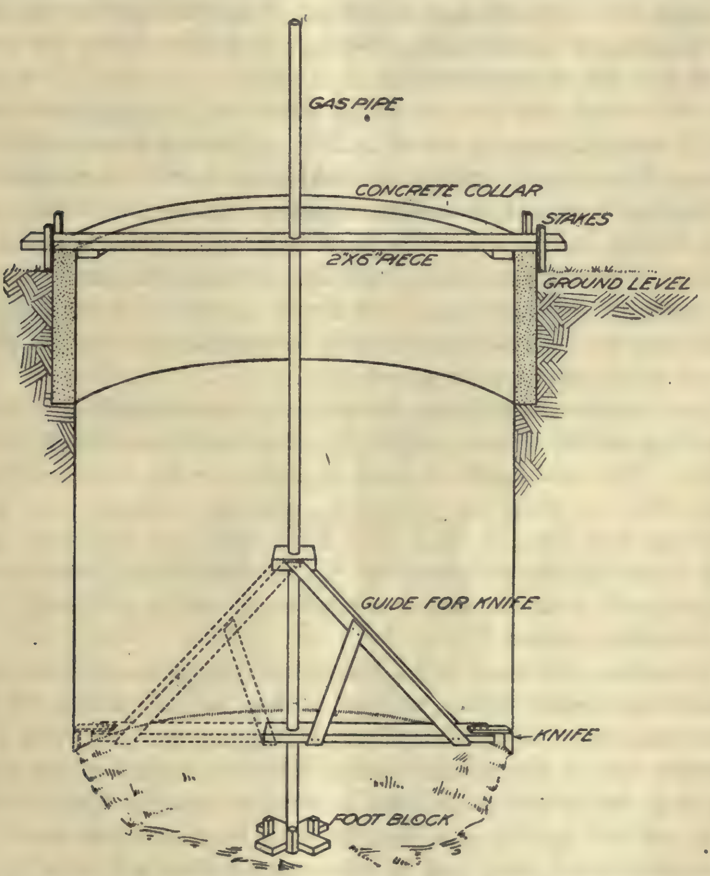

FIG. 2.—Vertical section of a partially constructed pit silo, showing a device for making the wall perpendicular and smooth. (Adapted from Circular No. 6 of the Extension Service of the University of Arizona College of Agriculture.

The stakes next to the curb and the blocks nailed on the lower surface of the 2 by 6 inch piece are put in place before the digging of the pit is started. The hole in the 2 by 6 inch piece through which the pipe passes is bored directly over the center of the silo. After each section of the pit is dug, the 2 by 6 inch piece is put in place, and a plumb line is dropped through the hole to locate the exact center in the bottom. Then the foot block is staked in place and the pipe lowered through the 2 by 6 piece, the guide, and into the hole in the foot block. The guide is then revolved, and the knife shaves the wall smooth, or indicates irregularities in the wall. When the wall has been smoothed to the approximate level of the foot block, the apparatus is removed, this section of the wall plastered, and digging then begun for the next section. This is repeated for each section of 5 or 6 feet excavated.

In soils which are not too sticky when wet, digging will be made easier if enough water is run in at night to soak up the ground in the bottom. When rocks are encountered they should be removed without blasting them, if possible. Careless blasting is likely to cause undue injury to the wall. In case blasting is done, no one should enter the pit after the blast until the air and poisonous gases have been replaced by fresh air. A limb of a tree, or a blanket, or the bucket used to lift out the soil may be used to agitate the air for a few minutes to remove the gases.

When the removal of rocks destroys the smooth surface of the wall, the defacements should be repaired by the use of metal lath or similar material. The metal lath or mesh should cover the damaged area and extend well out over the solid wall, and be fastened very securely with long iron pins, so that it is flush with the surrounding wall. Large holes in the wall may be partly filled with concrete before being covered with the lath. Adobe mud, where available, is often used for this purpose.

If a carrier and track is to convey the silage away from the silo, it should be erected before the pit is dug, so that it can be used to remove and carry away the soil when digging the pit. The hoisting apparatus can be set up and used to lift out the soil while the pit is being dug, but it will pay to use a horse or team to lift it. The soil may be utilized in filling in around the silo to make an elevated and well-drained feed yard, and it is important that a foot or so of dirt be banked up against the curbing to prevent water draining into the silo.

LINING THE PIT.

When 5 or 6 feet have been excavated, the wall should be plastered about 1 inch thick with a mortar made of 1 part cement and 2 or 2½ parts of clean, sharp sand. Two coats will be required to do this, and at least two hours should elapse between the application of the first and second coats; but the second coat should be applied before the first has become completely dry. A lining 1 inch thick is usually sufficient, but in soils which are not firm a 1½-inch wall would be safer.

Before applying the lining the wall should be dampened, in order to prevent the dry soil from absorbing the moisture too rapidly from the mortar. Before the plaster is set, apply one or two coats of a wash of pure cement and water, mixed to a creamy consistency. This may be done with a whitewash brush. The application of this last coat assists in making the wall stronger, smoother, air-tight, and almost waterproof. Keep the plastered wall damp for several days, as this will help the plaster to harden properly and a stronger wall will result.

It will be found desirable to leave bare an inch or so of the earth wall immediately below the curb until the silo is completely dug. This will allow the curb to settle without "buckling" or cracking of the lining below.

After the first section of 5 or 6 feet has been lined with the mortar and cement wash, digging may be resumed, and the work carried on in this way until the desired depth is reached. By completing the silo by sections in this manner the danger of caving in and the necessity of building scaffolding for the application of the lining are eliminated. Do not put mortar over the bottom. It should be left bare.

COMPLETING THE SILO.

A wall about 4 feet high is now built on the concrete curb. This may be of concrete, lumber, concrete blocks, hollow tile blocks, or brick. Woven-wire fencing has been used for this purpose; it is much better than nothing at all, as it will prevent persons or live stock from falling in, and when the silo is filled this wire wall can be filled also, so that upon settling the pit will be nearly full.

Forms are necessary for building a concrete wall, which should be about 4 inches thick and reinforced with heavy woven-wire fencing. It will be necessary to erect scaffolding across the top of the pit from which the inner forms can be suspended in place. Consult Farmers' Bulletin 589 for directions for building forms and making concrete walls. A wall approximately 4 feet high is desirable, as it adds that much depth to the silo and affords protection against falling in.

An inexpensive covering of some sort should be placed over the silo. A simple board roof is sufficient. It is best to leave a space of about 2 feet or more at the top of the wall to allow a free circulation of air around the top of the silo, which makes less probable the accumulation of poisonous gases.

Where a man furnishes all of his own labor, obtains sand and gravel at a small cost, and installs a homemade hoisting apparatus, a 150 to 180 ton silo may be constructed for a cash outlay of about $75, as the cement is the chief item of cash expenditure.

HOISTING DEVICES AND FEEDING EQUIPMENT.

The problem of hoisting and feeding silage from pit silos is not as formidable as it appears to many on first thought. This is evident to one observing the ease and rapidity with which feeding is done by farmers who have pit silos. Practically all of the devices now in use are homemade affairs, which are inexpensive. A few of the most successful of these are illustrated and briefly described herewith.

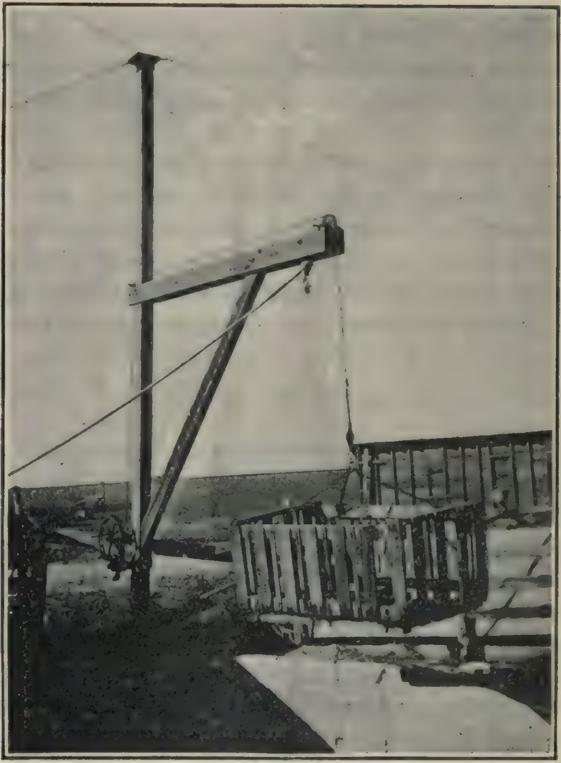

Fig. 3.—A simple type of hand hoist used in connection with a pit silo.

Figure 3 illustrates one of the most simple types in use. This device consists of a swinging crane, a windlass, pulleys and rope, and a box of some sort for the silage. A strong 4 by 6 inch piece may be used for the upright or mast, 2 by 6 or 2 by 8 inch pieces for the arm, and a 4 by 4 inch piece for the boom. Only sound timbers should be used. The windlass and the plates of iron on which the crane turns can be purchased at small cost. The upright should be braced from the top with heavy guy wires securely anchored. If desired, the windlass may be replaced by a pulley, and a horse or a team used to lift the silage. This is the common practice where large numbers of cattle are fed. The silage box after being filled and hoisted can be swung over a wagon or attached to a trolley on an overhead track, or placed upon a truck, as is shown in figures 5 and 6. Such a hoisting device may be placed so that it can be used to empty two or even three silos. Whatever kind of carrier for the silage is built or purchased, it should have a trip bottom, end, or side, so that it may be unloaded easily.

The illustration on the front page of this bulletin shows one way in which a regular hay carrier and outfit is used to feed silage from a pit silo. The track extends into the barn above or in front of the feed troughs. With the equipment shown here a horse is used to hoist the silage. However, it is possible to install a windlass for lifting the silage, and to use with this a simple trolley to which the silage carrier can be transferred after being filled and raised.

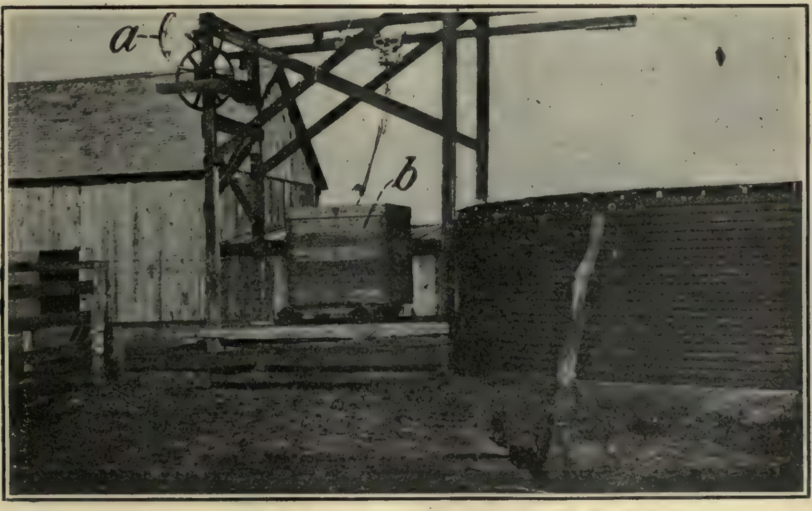

FIG. 4.—A well-inclosed pit silo, showing a combination hand hoist and hay carrier used to lift the silage. An endless rope or chain runs on the wheel "A" by which the windlass is operated. The silage box " B " is transferred to the truck and carried out along the continuous feed trough.

A type of hand hoist used in connection with a continuous feed trough is illustrated in figures 4 and 5. Over the wheel shown at "A" in figure 4 runs an endless rope or chain by which the windlass is operated. The drum or barrel on which the rope is wound when lifting the silage is shown at "A" in figure 5. In place of an overhead track and carrier, a truck is used to convey the silage out along the feed trough. The truck runs on the top edges of the 2-inch pieces that form the sides of the continuous trough arrangement shown in the figures. An overhead track and trolley could be used.

Figure 6 shows a large pit silo with a patented hoisting device, several of which are in use in the Texas Panhandle. With this hoist the feeder can lift himself and the silage out by the endless rope or chain which runs over the large wheel shown in the illustration. The silage carrier is transferred to the hooks on the trolley and run out over the feed trough.

With the framework over the silo constructed somewhat similar to that shown in figure 6, a horsepower hoist or a hand windlass could be installed. In case feeding could not be done near the silo, only a short track would be required to carry the silage to a wagon.

The kind of hoist and feeding equipment to be installed in connection with a pit silo should be determined largely by the amount of silage to be fed and the conditions which affect feeding. A farmer should install a hoist and equipment that conform to his particular needs and plans, keeping in mind the desirability of convenience, durability, and safety.

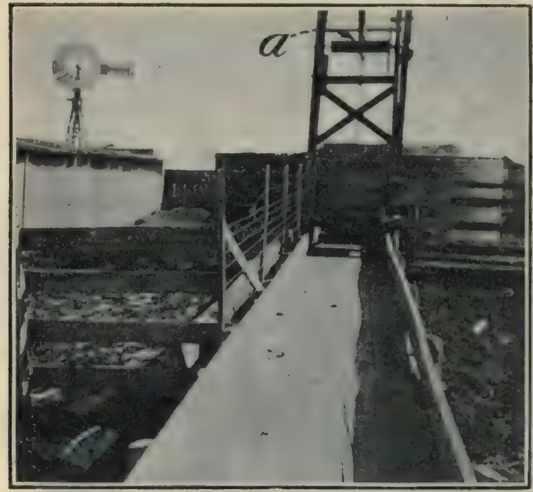

FIG. 5.—Another view of the silo and hoisting apparatus shown in figure 4. This illustrates the continuous feed trough, the top edges being used as a track for the truck. The barrel of the windlass on which the hoisting rope is wound is shown at "A."

POISONOUS GASES IN PIT SILOS.

Occasionally poisonous gases are formed in pit silos, and because the only means of ventilation is at the top, they may accumulate to such an extent that it is dangerous to enter. This formation and accumulation of dangerous gases practically always takes place only when the silo is partially filled with fresh silage. So particular care should be taken before entering a silo under those conditions. If a lighted lantern is lowered into the silo and continues to burn, it is safe to enter. When danger is suspected, thoroughly agitate the air, as mentioned in connection with blasting. Some farmers keep a rabbit in their pit silo, and as long as the rabbit is alive it is safe to enter. While very little trouble has been experienced from this source, it is well always to be certain that poisonous gases are not present before entering the pit silo.

POINTS TO BE EMPHASIZED.

Locate the silo so that feeding the silage can be done conveniently.

The silo must be in firm, well-drained soil, which should be free from sand strata and rocks.

Make the pit the proper size and depth, according to the amount of silage to be fed.

Make the bottom of the trench for the curbing or collar level, keep the inside of the trench smooth, and put in a substantial collar.

Keep the wall of the pit smooth and plumb.

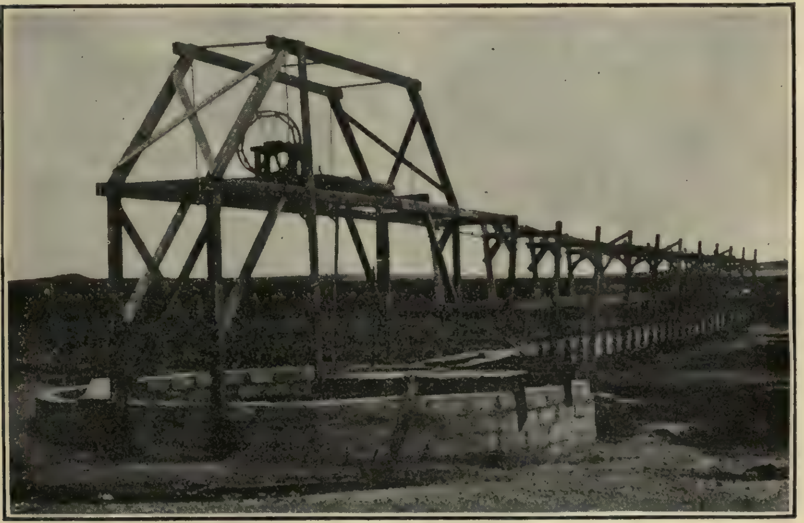

FIG. 6.—A large pit silo with the hoisting and feeding equipment used in connection. The hand hoist is patented. The silage is carried along on the track over the feed troughs. Framework over the troughs is made for a shed. Feeding can be done easily and rapidly with this equipment.

Make the mortar for the lining in the proportions indicated, first mixing well the sand and cement dry. Plaster this on to the dampened wall, as directed, and do not attempt to economize by making it less than 1 inch thick. Then keep the wall damp for several days.

Leave the bottom of the pit bare.

Remember that an efficient hoist greatly reduces the time and labor required to remove the silage.

Do not fail to inclose the pit with a wall of some sort, so that there will be no danger of anything falling into the silo.

Pit silos are usually constructed with the idea of permanency, so it is in the interest of economy and safety to construct them well.

PUBLICATIONS.

In connection with pit-silo construction the following bulletins are of value to farmers. They may be had upon request from the U. S. Department of Agriculture, Washington, D. C.

Farmers' Bulletin 461. Uses of Concrete on the Farm.

Farmers' Bulletin 481. Concrete Construction on the Live-Stock Farm.

Farmers' Bulletin 578. Making and Feeding Silage.

Farmers' Bulletin 589. Homemade Silos.

Farmers' Bulletin 724. Feeding Grain Sorghums to Live Stock.

○

INDEX.

	Farmers' Bulletin No.	Page.
Abattoir, municipal, aid in local marketing of live stock	809	12–13
Abortion, mare, causes and prevention	803	14
Alfalfa, composition and digestibility, comparison with other crops	820	24
Alkali, irrigated lands reclamation by drainage	805	26–29
Allograpta obliqua, aid in aphid control	804	34
Anthracnose, watermelon, description, cause, and control	821	3, 6–11
Antimony sulphid, use against tobacco budworm, efficiency	819	8
Aphids—		
control measures	804	34–42
eggs, destruction by pruning, note	804	41
enemies of	804	33–34
host plant destruction for control	804	42
injuries and control, summary	804	2
species, development, description, injuries, etc	804	2–34
spraying for control on various fruits, times, and methods	804	40–42
Aphis—		
avenae. See Oats aphis.		
bakeri. See Clover aphis.		
cardui, description, history, and injury to plums	804	20–21
cerasifoliae, description and habits	804	25
crataegifoliae. See Thorn-leaf aphis.		
houghtonensie, injury to gooseberries, description	804	31
malifoliae. See Rosy aphis.		
neomexianus, injury to currants in New Mexico	804	31
persicae-niger, description, habits, and history	804	26–27
pomi. See Green apple aphis.		
ribis, currant aphis, distribution and description	804	31
rumicis. See Dock aphis.		
sanborni, injury to gooseberries, description	804	31
setariae. See Rusty plum aphis.		
varians, injury to currants, description	804	30–31
Apple aphids, species, description, injuries, and spraying	804	5–18
ARNOLD, J. H., bulletin on "How live stock is handled in the bluegrass region of Kentucky."	812	1–14
Arsenicals, ineffectiveness against aphids	804	34
Asparagus bed, starting in small garden	818	42
ATWATER, HELEN W., and CAROLINE L. HUNT, bulletin on "How to select foods"—		
I. "What the body needs"	808	1–14
II. "Cereal foods"	817	1–23
III. "Foods rich in protein"	824	1–19
Auger, soil, for boring test pits in irrigated lands	805	8
BAKER, A. C., and A. L. QUAINTANCE, bulletin on "Aphids injurious to orchard fruits, currant, gooseberry, and grape"	804	1–42
Barn, combination, horse, cattle, and sheep, drawings and cost	810	13–15
Barns, sheep, plans, drawings, and cost	810	10–13, 15–17
Baths, preparations for use against mites and lice	801	25–26
Beans—		
cultural suggestions for vegetable gardens	818	37–39
protein content	824	4
Beef—		
baby—		
production	811	22
raising, advantages, and when not advisable	811	3–7
cattle, classification at county fairs	822	8–9
yearling, advantages	811	3–5

	Farmers' Bulletin No.	Page.
Beekeeping, advantage of sweet clover	820	32
Beetles, ladybird, aid in aphid destruction and control	804	34
Beets—		
growing in vegetable garden, cultural suggestions	818	31
harvesting and storing for sirup making	823	6–8
sirup, making on farm	823	1–13
sugar—		
growing, for sirup, cultural directions	823	3–9
irrigation directions	823	6
sirup making, directions	823	3–9
storing for sirup making	823	7–8
Bermuda grass—		
analysis and digestibility, comparison with timothy and Kentucky bluegrass	814	17
description, history, climatic, and soil adaptations, and distribution	814	3–6, 18
eradication methods	814	18
growing and use	814	29
variant names	814	4
varieties, description, and value comparisons	814	7–8, 19
Berries, growing in small home garden	818	44
Biscuits, recipe	817	12–13
BISHOPP, F. C., and H. P. WOOD, bulletin on "Mites and lice on poultry"	801	1–27
Black cherry aphis, description and history	804	22–24
Black medic, value with Bermuda grass pasture	814	12
Bloat, cattle, treatment	820	9–10
Blossom-end rot. *See* Rot.		
Bluegrass—		
Kentucky, analysis and digestibility, comparison with Bermuda grass and timothy	814	17
region—		
adaptability to live-stock industry	812	3–6
farm conditions, topography, soil, etc	812	3–5
Body louse, poultry, description and control	801	14–15, 19, 26
Bonds, drainage, issues and proceeds	815	20–26
Bordeaux mixture—		
homemade, formula and directions	821	9–10
use in control of vegetable diseases	818	26
Branding, sheep, practices	810	25–27
Bread—		
food value, cooking directions and recipes	817	9–14
good, qualities	807	4–5
making—		
directions and recipes	817	9–14
home	807	26
nutritive value, place in diet, etc	807	24–25
protein content	824	4
recipes	807	14–23
waste, utilization, recipes	817	17–21
Breads, corn, recipes	817	13–14
Breakfast cereals, kinds, value, and preparation	817	14–16, 19
Breeding herd, baby beef, management, and feeding	811	10–17
Breeding, horse, suggestions for farmers	803	1–22
Breeds, cattle, for baby beef production, and type of cows, etc	811	7–9
Brussels sprouts, growing for small gardens, cultural hints	818	40
Buckeye chicken, description	806	18
Budworm, tobacco—		
and its control in the southern tobacco districts	812	1–12
description, distribution, and injurious habits	819	35
Buildings, sheep, plans, requirements, etc	810	3–18
Bulkhead, outlet of drainage system, description	805	22

	Farmers' Bulletin No.	Page.
Bull—		
management, feeding, etc	811	12
selection for baby-beef production	811	8–9
Bur clover—		
aphis, injuries to apple blossoms	804	18
value with Bermuda grass pasture	814	12
Butter, tainting from sweet clover, prevention	820	9
Cabbage, growing for small gardens, cultural hints	818	40, 43
Cake, sponge, recipe	824	16
Calves—		
dehorning, castration, and vaccination	811	17
fall—		
advantages	811	15
and spring production, herd management, calendar	811	14
fall-born, management for baby beef, calendar	811	20
feeding for baby beef, different systems	811	16–17, 20, 21
selection for baby-beef production	811	9
spring-born, management for baby beef, calendar	811	19
Canals, weirs, advantages and objections of use	813	4–5
Capriola dactylon. *See* Bermuda grass.		
Carbolic-acid-gasoline mixture, use in lice control on fowls	801	25
Carrots, growing, early and for winter use	818	43
Castration, calves	811	17
Cattle—		
baby beef production	811	1–22
beef, blue-grass region, buying and management	812	7
bloat, control treatment	820	9–10
bloated, treatment	820	9–10
classification at county fairs	822	8–9
dips, arsenical, use in control of chicken mites, method and warning	801	7–8
equipment for farm	816	9
feeding for market, estimation of profits	812	9–10
marketing, methods in South Carolina	809	9–10
number to acre on bluegrass farms	812	4–6
pasturing on sweet clover, management	820	23
Cereal foods—		
economies, waste prevention	817	17–21
place in diet	817	1–23
Cereals, prepared, nature, comparisons, etc	817	5–6
Chard, Swiss, growing for greens, cultural notes	818	41
Cheese—		
fondue, recipe	817	18
protein content	824	4
Cherry aphids, distribution, habits, and history	804	22–25
Chicken houses, mite-infested, treatment, sprays, dips, etc	801	6–8, 26
Chickens—		
American class of standard varieties	806	19
breeds and varieties, American, descriptions, mating, etc	806	5–18
mites and lice, occurrence and control	801	3–17, 19–26
Plymouth Rock. *See* Plymouth Rock.		
Rhode Island Red. *See* Rhode Island Red.		
varieties, standard 1, the American class	806	19
Wyandotte. *See* Wyandotte chickens.		
Chiggers—		
chicken pests, description, other names, and control treatment	801	11
occurrence on poultry, control	801	10
Chowder, salt codfish	824	13–14
Classifications, live-stock exhibits at county fairs	822	8–12

	Farmers' Bulletin No.	Page.
Clover—		
aphis, distribution, description, history, and injuries to apples	804	15–16, 19
red, composition and digestibility, comparison with other crops	820	24
sweet, utilization	820	1–32
white, value in lawns	814	14
Clubs, lamb and wool, organization and operation in Tennessee	809	7–8
Cnemidocoptes, spp., occurrence on poultry, control	801	10,19–26
Coal ashes, sifted, value in garden soil	818	15
COE, H. S., bulletin on "Sweet clover: Utilization"	820	1–23
Cold frame, use for hardening plants	818	12
Colletotrichum lagenarium, cause of anthracnose of watermelon	821	7
Color, cotton, standards and factors influencing	802	9–10
Colostrum, mares', need by foal	803	16
Colt, weaning, management and suggestions	803	18–19
Colts, care and feeding	803	19–21
CONE, VICTOR M., bulletin on "Construction and use of farm weirs"	813	1–19
Cooking—		
breakfast cereals, directions	817	15–16, 19
suggestions for foods rich in protein	824	12–18
Cooperation, drainage—		
irrigated farms, necessity and advantages	805	30–31
work, necessity and advantages	805	30–31
Cooperative-live-stock shipping, advantages for South	809	5–9
Corn—		
breads, recipes	817	13–14
cultural suggestions	818	35
husking, seed testing, etc., equipment	816	10
meal, use in bread making	807	21
scalloped, recipe	824	17
silage, composition, comparison with sweet clover silage	820	22
Cotton—		
American upland, classification, bulletin by D. E. Earle and Fred Taylor	802	1–28
classification, purposes	801	4
color, standards and factors influencing	802	10–12
Liverpool standards	802	25–26
standards, use in classifying and grading	802	18–22
trade names and regional characteristics	802	14–18
Cottonseed meal, feeding to hogs with grain, directions	809	14
Couch grass. *See* Bermuda grass.		
Cows—		
feeding, breeding, etc., for baby-beef production	811	13–14
milk, pasturing on sweet clover, management	820	6, 9
selection for baby-beef production	811	7–8
Crop rotations, place of sweet clover	820	31
Crops—		
choosing for small vegetable garden	818	8–9
successive, vegetable garden	818	22–24
Cucumbers, growing for small gardens, cultural hints	818	39–40
Currant aphids—		
distribution, habits, and history	804	27–31
injurious, and to orchard fruits, gooseberry and grape	804	1–42
Custard, baked, recipe	824	16
Cynodon dactylon. *See* Bermuda grass.		
Dairy—		
cows, feeding Bermuda hay, cost of milk and butter, comparisons with other feeds	814	15–16
equipment, articles and prices	816	9
Dehorning calves	811	17
Depluming mite, occurrence on poultry, injury and control	801	10, 19–26
Dermanyssus gallinae. *See* Mite, chicken.		
Devil grass. *See* Bermuda grass.		

	Farmers' Bulletin No.	Page.
Diet—		
adequacy, judging	808	11–12
importance of bread	807	3–4
protein needs and sources	824	1–19
Diseases, watermelon, description, causes, and control	821	1–18
Ditches—		
drainage—		
irrigated lands, objections, cost, and maintenance	805	14–16
maintenance in district organization, importance of management	815	35
weir, advantages and objections	813	4–5
Dock aphis, description, and injury to apples	804	17
Dog's-tooth grass. *See* Bermuda grass.		
Dominique chicken, description	806	15–16
DOTY, S. W., bulletin on "Marketing live stock in the South: Suggestions for Improvement"	809	1–16
Drainage—		
cooperation in irrigated districts	805	30–31
district—		
administration, selection and duties of officials	815	32–34
organization, financing, and administration	815	1–37
irrigated farms	805	1–31
maintenance, directions	805	29–30
organizations, development, rights, advantages, etc	815	4–7
records of districts, systems, importance	815	29–32
testing requirements	805	8–9
Drains—		
construction on irrigated lands, methods, devices, and costs	805	14–26
irrigated lands, depth, spacing, and location	805	9–14
open and covered, costs comparison	805	16
Driving equipment for horse	816	8–9
Ducks, treatment for lice	801	18–26
Dust bath, value for fowls	801	26
Dwarf fruit trees, desirability for small home garden	818	44
EARLE, D. E., and FRED TAYLOR, bulletin on "Classification of American uplands cotton"	802	1–28
Education, value of live-stock exhibits	822	3
Eggplants, cultural suggestions	818	36–37
Eggs—		
nest, medicated, use in lice control, dangers	801	25–26
production, effect of mice and lice	801	3
protein content	824	4
Ensiling, sweet clover, management and suggestions	820	20–22
Eriosoma lanigerum. *See* Woolly aphides.		
Erosion, soil, value of Bermuda grass	814	14
Exhibits, live-stock, arrangements and placarding	822	5–6
Fairs—		
exhibits, rules governing	822	6–7
live-stock classification	822	1–12
rules for live-stock classification	822	6–7
Farm—		
business, bluegrass region, analysis of six individual farms	812	11–14
equipment, minor articles	816	1–15
weirs, construction and use	813	19
Farmers, horse-breeding, suggestions	803	1–22
Farms, irrigated, drainage	805	1–31
Feed—		
Bermuda hay, comparison with other hays	814	15–18
racks, sheep, description and use	810	18–21
sugar beets, value	823	4

Farmers' Bulletin No. — Page.

- Feeding—
  - calves for baby beef, different systems 811 16–17, 20, 21
  - cattle, in baby-beef production 811 11–14
  - colt, motherless, directions 803 17–21
  - hogs—
    - causes of soft and hard pork 809 13–14
    - for hardening pork 809 13–14
  - mare, and management, before and after foaling 803 11–14, 16–17
  - sweet clover 820 23–28
- Feeds—
  - steer requirements, or equivalent in sheep or swine 812 8
  - succulent, for mares and colts 803 14, 20
- Fencing, sheep, dog-proof, and other 810 23–25
- Fertilizers, vegetable garden 818 16
- Fish, scalloped, recipe 824 14
- Flat. *See* Seed box.
- Flies, syrphus, lacewing, and four-winged, aid in aphid control 804 34
- Flour, requirements for bread making 807 5–7
- Fluff louse, description, occurrence on poultry, and control 801 16–17, 19–26
- Foal—
  - care at birth and later 803 15–19
  - orphan, raising by hand, formulas for milk, etc 803 17–18
    - *See also* Colt.
- Foaling, care of mare and young 803 14–17
- Food—
  - constituents, requirements of human body 808 7–8
  - groups for various uses 808 8–11
  - habits, importance 808 14
  - materials, protein amounts and proportions 824 4, 6–9
  - selection. II. Cereal foods 817 1–23
- Foods—
  - cereal, use in diet 817 1–23
  - groups 817 3–4
  - protein, cooking recipes 824 12–17
  - selection for protein 824 1–19
  - what the body needs 808 1–14
- Four-winged flies, larvae, aid in aphid control 804 34
- Fruits—
  - garden, berries and tree fruits 818 44
  - orchard, aphids injurious, and to currant, gooseberry, and grape 804 1–42
- Fungus, cause of anthracnose in watermelon, description 821 7
- Futurity contests, live stock at county fairs 822 4–5

- Garden—
  - back-yard, plan 818 7
  - choosing crops for family of four 818 8–9
  - small, planning 818 4–8
  - vegetable, small, suggestions for utilizing limited areas 818 1–44
- Gardener, planting table, seed quantity, dates, etc 818 18–19
- Gardening, essentials for success 818 3–4
- Gas, silo, control 825 12
- Gauge, weir, description and adjustment 813 10–12
- Geese, lice treatment 801 18–26
- Gingerbread, recipe 817 19
- Goats, classification at county fairs 822 11
- Gooseberry aphids—
  - distribution, habits and history 804 31
  - injurious, and to orchard fruits, currant, and grape 804 1–42
- GORE, H. C., and C. O. TOWNSEND, bulletin on "Sugar-beet sirup" 823 1–13
- Grades, cotton, classification, names and factors determining 802 4–9
- Grain, equipment for handling, minor articles 816 11
- Grains, feeding brood mares 803 12–13

	Farmers' Bulletin No.	Page.
Grape, aphids—		
injurious, and to orchard fruits, currant, and gooseberry	804	1–42
injury to grape foliage	804	32–33
Grapevine aphis, description, history, and injuries	804	33
Grass, Bermuda, growing and use	814	1–29
Grazing—		
Bermuda grass pastures, management	814	10–11
habits, live stock	812	6–9
Green-apple aphis, description	804	10–13
Ground rot. *See* Rot.		
Guineas, treatment for lice	801	19–26
HART, R. A., bulletin on "The drainage of irrigated farms"	805	1–31
Harvest mites. *See* Chiggers.		
Harvesting, sugar-beet, and storing for sirup making	823	6–8
Hay—		
Bermuda grass, value, comparisons with other hays	814	13, 14–18, 19
color, importance in marketing	814	15
equipment for handling and storing	816	11
sweet clover—		
cutting methods, curing and handling	820	12–20
feed value, cutting time, yield, etc	820	10–12
Hays, composition and digestibility of various kinds	820	24
Head louse, poultry, description and control	801	13–14, 19–26
Heifers, feeding and breeding, for baby-beef production	811	14
Hen—		
house, treatment for lice and mites	801	6–9
louse, description and control	801	13–17 19–26
Herd, silage requirements for winter feeding	825	5
Hogging down crops, advantages in bluegrass region	812	6–7
Hogs—		
classification at county fairs	822	10
equipment for farm	816	10
feeding—		
and grazing, useful habits on live stock farms	812	7, 9, 10
for hardening flesh, experiments	809	13–14
on sweet clover pasture, comparison with other pastures	820	10–12
to harden pork	809	13–14
following cattle, management and advantages	811	22
Hoisting equipment for pit silos	825	10–12
Home bread making	807	26
Honey—		
plant for production, value, and management of sweet clover	820	32
sweet clover, characteristics	820	32
Hop aphis, description, habits, history, and injury to plum	804	21–22
Horse—		
breeding, suggestions for farmers	803	1–22
equipment for driving, articles and prices	816	8–9
Horses—		
classification at county fairs	822	11
defects constituting unsoundness	803	6–8
soundness, requirements by breeders	803	6–8
Hotbed, making and use, directions	812	11–12
Housekeepers, planning meals, aid from food groups	808	10–11
HUMPHREY, H. N., and A. P. YERKES, bulletin on "Minor articles of farm equipment"	816	1–15
HUNT, CAROLINE L., and HELEN W. ATWATER—		
bulletin on "How to select foods. I. What the body needs"	808	1–14
bulletin on "How to select foods. II. Cereal Foods"	817	1–23
bulletin on "How to select foods. III. Foods rich in protein".	824	1–19
HUNT, CAROLINE L., and HANNAH L. WESSLING, bulletin on "Bread and bread making in the home"	807	1–26
Hurdle, sheep, construction	810	22, 23–25

	Farmers' Bulletin No.	Page.
Hyadaphis xylostei. *See* Wild-carrot aphis.		
Hyalopterus arundinis, description and habits	804	22
Hydraulic equivalents, units of measure, table	813	18
Ice plant—		
market for meats in South	809	11-12
southern, as local market, various States	809	11-12
Indian—		
couch grass. *See* Bermuda grass.		
pudding, recipe	817	19
Insects—		
affecting man and animal, list	801	27
enemies of budworm of tobacco	819	6
parasitic and predaceous, aid in aphid control	804	33–34
vegetable, control directions	818	26–27
Irrigated farms, drainage	805	1-31
Itch mite, description and injury to poultry	801	10
Jacks, classification at county fairs	822	12
Java chicken, description	806	14–15
Judges, county fair, selection	822	5
Judging, contests, live stock at county fairs	822	5
Kerosene emulsion—		
use for control of chicken mites, method	801	7, 10
use in aphid spraying, formula	804	38–39
Kraut cutter, use in making sugar-beet sirup	823	11
Labor income, definition	812	4
Lacewing flies, larvae, aid in aphid control	804	34
Lambing, pens and creeps for sheep raising on farms	810	22–23
Lambs, feeding experiments with different hays	820	25–26
Lands, irrigated—		
drainage needs and beneficial results	805	3–8
underdrainage, beneficial results	805	8–9
Lawns, Bermuda grass sod, advantages	814	13–14
Lead arsenate—		
use against tobacco budworm, efficiency	819	8, 9
use in vegetable garden	818	26–27
Lespedeza, value with Bermuda grass pasture	814	11–12
Lettuce, cultural suggestions	818	28–29
Lice—		
chicken—		
injuries to turkeys, poults, and ducks, control method	801	12, 17–18, 19–26
varieties, injuries, food habits, control, etc	801	11–17, 19–26
colts', detection and eradication	803	19
poultry, and mites, bulletin by F. C. Bishopp and H. P. Wood	801	1–27
Lime, value to garden soil	818	15–16
Lipeurus heterographus, description, occurrence on poultry and control measures	801	13–14, 19–26
Live stock—		
classification at county fairs	822	1–12
cooperative handling and shipping, advantages	809	5–9
exhibitions, educational value	822	3
exhibits at fairs, rules	822	6–7
feed, cost, and feeding practices, bluegrass region	812	7–10
marketing in the South, improvement suggestions	809	1–16
number per acre on bluegrass farms	812	6
raising in bluegrass region, relation to profitable farming, discussion	812	3–6
Macrosiphum illinoiensis. *See* Grapevine aphis.		
Macrosiphum solanifoliae. *See* Potato aphis.		

	Farmers' Bulletin No.	Page.
Malnutrition, watermelon, description	821	17
Man—		
food needs	808	1–14
protein requirements	824	5–6
Manhole, drainage system, description	805	22–23
Manienie grass. *See* Bermuda, grass.		
Mares—		
brood, feed and management before and after foaling	803	11–14, 16–17
feeding after foaling	803	16–17
parturition, management	803	14–15
profits on farms	803	3–4
selection for breeding and farm work	803	4–7
Marketing—		
clubs, live stock, organization and operation	809	7–9
live stock in the South, improvement, suggestions	809	1–16
live stock, practices in South	809	3–5
Mating, horses in breeding	803	9–11
McDonough, F. L., and A. C. Morgan, bulletin on "The tobacco budworm and its control in the southern tobacco districts."	818	1–12
McWhorter, V. O., bulletin on "Equipment for farm sheep raising"	810	1–28
Meal, corn, use in bread making	807	21
Meals, food for family, sample	808	6
Meat, protein content	824	4
Meats—		
farm cured marketing suggestions	809	10–11
live-weight prices, comparison with dead-weight prices	809	14–15
Melilotus, value with Bermuda grass pasture	814	12
Menopon biseriatum, description, occurrence on poultry and control	801	14, 19–26
Metcalfe, T. Pryse, and George A. Scott, bulletin on "Pit silos"	825	1–14
Mildew, downy, disease of watermelon, control	821	17
Milk—		
composition, cows' and mares'	803	17
protein content	824	4
tainting, from sweet clover pasturage	820	9
Milling, wheat, for white flour, processes	807	5–6
Mite, scaly-leg, description and control	801	10
Mites—		
common chicken, description, distribution, life history, spread methods, and control	801	3–10
poultry, and lice, bulletin by F. C. Bishopp and H. P. Wood	801	1–27
Money, drainage, raising by cash certificates and bonds	815	19–26
Morgan, A. C., and F. L. McDonough, bulletin on "The tobacco budworm and its control in the Southern tobacco districts"	819	1–12
Mortar, lining for pit silos, formula	825	8–9
Mowing, sweet clover, suggestions	820	12–23
Mules, classification at county fairs	822	12
Mustard, growing for greens, culture notes	818	41
Myzus—		
cerasi, description, history, and injury to cherries	804	22–24
dispar, similarity to currant aphis	804	30
ribis. *See* Currant aphis.		
Navel, prevention of infection in foal	803	16
Nest egg, medicated, use in lice control, danger	801	26
Nests, poultry, construction and treatment for control of mites	801	9
Nicotine—		
extracts, home-made, formula	804	36–38
solutions, value in aphid control, formulas	804	35–38
Nut bread, recipe	807	22
Oats, aphis, description, history, and injuries to apples	804	13–15, 19
Onions, cultural suggestions for small gardens	818	30–31

	Farmers' Bulletin No.	Page.
ORTON, W. A., bulletin on "Watermelon diseases"	821	1–18
Parasites, external, of poultry	801	1–27
Paris green, use against tobacco budworm, objections and efficiency	819	7, 8
Parsley, cultural suggestions	818	42
Parsnips, growing for winter use	818	43
Parturition, mares, treatment of dam and foal	803	15–16
Pastries, food value, suggestions, etc	817	16–17
Pasture—		
area per head of stock, bluegrass farms	812	11, 12, 13
sweet clover, use and value	820	3, 4–10
Pastures, South, value of Bermuda grass	814	10–12, 19
Pea hay, composition and digestibility, comparison with other hays	820	24
Peach aphids, description and history	804	25–27
Peafowl, treatment for lice	801	19–26
Peanuts, hog feeding, effect on pork	809	13–14
Pear aphids, description and injuries	804	18–19
Peas, cultural suggestions	818	29–30
Peppers, cultural directions	818	36–37
Petroleum, crude, with kerosene, use in spraying poultry mites and use method	801	7, 10
Phorodon humuli. *See* Hop aphis.		
Pigeons, injury by lice and control	801	19–26
Pit silos, construction, details	825	1–14
Placards, value in live-stock exhibits	822	6
Planting table, garden seeds, time of planting, and maturity	818	18–19
Plants, setting out, directions	818	21–22
Plum aphids, distribution, description, and injuries	804	19–22
Plymouth Rock chickens, origin, description, mating, and judging	806	5–11
Ponies, classification at county fairs	822	12
Pork—		
and beans, baked, recipe	824	13
curing and handling by ice companies in South, costs	809	11–12
soft, cause and remedy	809	13–14
southern, discrimination against	809	13–15
Potato aphis, injury to apples, description	804	17
Potatoes—		
cultural suggestions, spacing, etc	818	32–35
tools for handling	816	12
use as cereal, discussion	817	21
Poultry		
classification at county fairs	822	12
equipment for farm	816	10
houses, sanitary requirements and studies	801	26
injury from mites and lice	801	3
lice, control treatment, time and method	801	19–26
mites and lice, bulletin by F. C. Bishopp and H. P. Wood	801	1–27
pests, method of avoiding	801	26
roosts, treatment for mites	801	8–9
Premiums, live-stock exhibits	822	7–8
Prize winners, parades at fairs	822	6
Procipilus corrugatans. *See* Woolly aphides.		
Protein—		
cost in different foods	824	10–12
different kinds	824	9–10
foods, rich in	824	1–19
Publications, insect, list of Department, for pests of animal and man	801	27
Pudding, farina, recipe	817	19
Puree, dried-bean recipe	824	16–17
QUAINTANCE, A. L., and A. C. BAKER, bulletin on "Aphids injurious to orchard fruits, currant, gooseberry, and grape"	804	1–42
Quince aphids, description and history	804	18

	Farmers' Bulletin No.	Page.
Racks, feed, for sheep, description and use	810	18–21
Radishes, cultural suggestions	818	28
Rations—		
calf, for baby beef	811	21–22
cattle, for baby-beef production	811	13–14
family, suggestions, place of cereals, etc	817	8
Ray, S. H., bulletin on—		
"Live-stock classifications at county fairs"	822	1–12
"The production of baby beef"	811	1–22
Recipes—		
bread	807	14–23
protein-rich foods	824	12–17
stale bread	817	18–21
"Red bugs," occurrence on poultry, control	801	11
Reese, H. H., bulletin on "Horse-breeding suggestions for farmers"	803	1–22
Rhexia virginia, infection with tobacco budworm, notes	819	5, 6
Rhode Island Red chickens, origin, description, and judging	806	17–18
Rhopalosiphum—		
lactucæ, description, history, and injury to currants	804	28–29
persicæ, description, habits, and history	804	25–26
Rhubarb bed, starting in small garden	818	42
Rice bread, recipe	807	21–22
Rolled-oats bread, recipe	807	22–23
Roosts, poultry, treatment for control of mites	801	8–9
Root crops, garden, cultural suggestions	818	31–32
Root-knot, watermelon, description, cause, and control	821	3, 6
Rosy aphis, injury to apples, description	804	5–10
Rot—		
blossem-end, watermelon, description and control	821	17–18
ground, watermelon, description and control	821	18
stem-end, watermelon, description, cause, relations, and control	821	3, 11–17
Rotation, crop, for control of watermelon diseases	821	5, 6
Rotations, vegetable gardens	818	22–24
Roughage, feeding brood mares	803	13
Rusty plum aphis, description, habits, and history	804	19–20
Rye, bread recipe	807	22
Sclerotium rolfsii fungus causing ground rot of watermelon	821	18
Score card, bread	807	23–24
Scott, George A., and T. Pryse Metcalfe, bulletin on "Pit silos"	825	1–14
Scours—		
colts, cause and treatment	803	18
foal, cause and treatment	803	18
Scutch-grass. *See* Bermuda grass.		
Seed—		
Bermuda grass, production, and propagation methods	814	8–10
beds, small gardens	818	20
box, early vegetables, directions for making and using	818	10–11
sugar beet, production directions	823	8–9
Seeds—		
planting in berry boxes for early start	818	10
vegetable, planting in drills, rows, and hills	818	20–21
Shaft louse, description, occurrence on poultry, and control	801	15–16, 19–26
Shallot, description and use	818	31
Shearing, sheep, equipment	810	27
Sheep—		
barns and sheds, plans, drawings, and cost	810	10–13, 15–17
classification at county fairs	822	10
feeding racks and troughs	810	18–22
grazing habits, usefulness on farms	812	6, 8–9, 10
marking, equipment and practices	810	25–27
raising on farm, equipment	810	28

	Farmers' Bulletin No.	Page.
Shipping—		
crate, sheep, construction	810	24, 26
live stock, cooperation, advantages for South	809	5–7
Silage—		
hoisting from pit silos, devices and equipment	825	10–12
sweet clover, comparison with other silage	820	3, 4–10
Silos, pit—		
advantages and adaptations	825	3–4
construction, details	825	1–14
Siphocoryne nympaeae, history, and injury to plums	804	21
Sirup, beet—		
directions for making, quality, and uses	823	9–13
making on farm	823	1–13
SLOCUM, ROB R., bulletin on "Standard varieties of chickens"	806	1–19
Soap—		
fish-oil, use in aphid spraying, formula	804	38
solution, use as dip for lice control, cautions	801	25
Sodium fluorid, use in control of animal lice, use method, and cost	801	20–24
Soil—		
improvement by sweet clover	820	3–4, 28–31
preparation, vegetable garden	818	4, 14–16
texture improvement in preparing for vegetables	818	15–16
Soiling crop, sweet clover	820	22–23
Solanum spp., infestation with tobacco budworm	819	6
South, live stock marketing methods, improvement suggestions	809	16
Soy beans, baked, recipe	824	13
Spinach, growing for greens, cultural notes	818	41
Spraying—		
orchard aphid control, time and method	804	34–35
watermelons—		
apparatus, sprays, cost, etc	821	8–11
for control of anthracnose	821	8–11, 15
Sprays, aphid control, formulas	804	35–42
Squashes, growing for small gardens, cultural hints	818	39–40
Stall, colts', called creep stall	803	17
Stallion, selection in horse breeding	803	8–9
Standards—		
chicken, American class	806	1–18
cotton, use in classifying and grading	802	18–22
Steers, feeding experiments with various hays	820	26–28
Stem blight, watermelon, description and control	821	17
Stem-end rot. *See* Rot.		
Stew, beef and bean, recipe	824	13
Sugar, maple, equipment for making, minor articles	816	12
Sulphur—		
ointment, use in chigger control	801	11
use against poultry lice	801	25
use in lice control, cost, dangers, etc	801	24–25
Sweet clover—		
composition and digestibility	820	24–25
pasture, management, value, etc	820	4–9
utilization	820	1–32
value and management as honey plant	820	32
Swine, equipment for farm	816	10
Syrphus fly larvae, aid in aphid control	804	34
TAYLOR, FRED, and D. E. EARLE, bulletin on "Classification of American upland cotton"	802	1–28
Tax, drainage, levy and collection	815	18–19, 26–28, 35
Testing, drainage requirements of irrigated farms; pits, wells, etc	805	8–9
Thorn-leaf aphis, description	804	18
Tick, cattle, elimination, effect on marketing cattle	809	16
Tile—		
cleaning devices, description and use	805	29–30
laying in drainage of irrigated lands	805	20

	Farmers' Bulletin No.	Page
Tiles, sizes for drainages of irrigated lands	805	16–18
Timothy—		
analysis and digestibility, comparison with Kentucky bluegrass and Bermuda grass	814	17
hay, composition and digestibility, comparison with other hays	820	24
Tobacco—		
growing—		
in bluegrass region, percentage of farms, importance, etc	812	3–5
man labor required	812	4
injury by budworms	819	4, 5
Togo beans, baked, recipe	824	13
Tools—		
farm, and minor articles of farm equipment	816	1–15
garden, description and use	818	12–14
general purpose, useful on farms, list and prices	816	4–7
special, useful on farms, lists and prices	816	8–12
Tomatoes, cultural suggestions for vegetable gardens	818	35–36
TOWNSEND, C. O., and H. C. GORE, bulletin on "Sugar-beet sirup"	823	1–13
Toxoneura sp., enemy of tobacco budworm	819	6
TRACY, SAMUEL M., bulletin on "Bermuda grass"	814	1–19
Transplanting, benefit to roots of vegetables	818	9, 10, 22
Trenching, drain, in irrigated lands, methods and machines	805	18–22
Trocar, use in treatment of bloat in cattle and sheep	820	9–10
Turkeys, treatment for lice	801	17–26
Turnips, growing for winter use	818	43
Underdrainage, irrigated lands, beneficial results	805	48
Variable currant aphis, description, injuries, and history	804	30–31
Vegetable garden, small, suggestions for utilizing limited areas	818	1–44
Vegetables—		
cultivation, prevention of crusts on surface	818	24–25
cultural suggestions	818	28–42
early, aids to growing, seed box, hotbed, etc	818	9–12
garden, protection against insects and diseases	818	25–27
growing for winter use, storing, etc	818	43
planting in open, dates, depths, and other details	818	16–24
Waste—		
prevention in use of cereal foods	817	17–21
products, utilization by animals	812	6, 10
Water, Bermuda, note	814	5
Watering troughs, sheep, descriptions	810	25, 26
Watermelon—		
anthracnose, description, cause, and control	821	3, 6–11
diseases—		
description, causes, and control	821	1–18
key	821	3
minor	821	17–18
resistant varieties to wilt	821	5
root-knot, description, cause, and control	821	3, 6
spraying for control of anthracnose	821	8–11, 15
stem-end rot, description, cause, and control	821	3, 11–17
wilt, description, cause, and control	821	3, 4–6
Weaning—		
colts, management and suggestions	803	18–19
foal, time and methods	803	19
Weir—		
definition, and use of related terms	813	3–4
gauge, description and location	813	10–12
Weir-box, dimensions for different types of weir	813	6
Weirs—		
discharge tables for different types	813	13, 15, 17
farm, construction and use	813	19
types, descriptions and operation	813	5–17
use on farm, advantages and objections	813	4–5

	Farmers' Bulletin No.	Page.
Wells—		
observation, on irrigated farms, need and use	805	9, 23–24
relief, in drainage system for irrigated lands	805	13, 25
WESSLING, HANNAH L., and CAROLINE L. HUNT, bulletin on "Bread and bread making in the home"	807	1–26
Wheat—		
breads, recipes	807	14–21
milling process for white flour	807	5–6
Whitewash, carbolic acid or cresol, use in control of chicken mites	801	8
Wild-carrot aphis, injury to apples	804	18
Wilt—		
bacterial, watermelon, description	821	17
watermelon, description, cause, and control	821	3 4–6
Wing louse, poultry, description and control	801	16, 19–26
Winter, vegetable garden	818	43
Wire-grass. *See* Bermuda grass.		
WOOD, H. P., and F. C. BISHOPP, bulletin on "Mites and lice on poultry"	801	1–27
Wood preserver, use in control of chicken mites, method	801	7
Wool and lamb clubs, Tennessee, organization and operation	809	7–8
Woolly aphides, descriptions and injuries	804	16–17, 19
Wounds, colts, treatment	803	21
Wyandotte chickens, origin, description, and judging	806	11–14
Yeast, nature and use in bread making	807	7–9
Yeasts, varieties, preparation and value	807	8–9
YERKES, A. P., and H. N. HUMPHREY, bulletin on "Minor articles of farm equipment"	816	1–15
YOHE, H. S., bulletin on "Organization, financing, and administration of drainage districts"	815	1–37

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